Indian Head Division
Naval Surface Warfare Center
Indian Head, MD 20640-5035

IHTR 2573
15 March 2004

SENSITIVITY TESTING OF CONTAMINATED SURFACES TO ESTABLISH NONREACTIVITY LEVELS AT ENERGETIC PROCESSING FACILITIES

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14. ABSTRACT

The downsizing and closing of military facilities have generated the need to eliminate potential explosive hazards from facilities previously used to process energetic materials. Testing for contamination levels of such hazards is an established practice; however, there are no established criteria for determining safe levels of the contamination. Small-scale sensitivity testing was performed to establish levels of contamination that would not exhibit reactions to normally executed construction practices, such as equipment installation and facility remodeling. Standard friction, impact, and electrostatic discharge (ESD) sensitivity tests were selected as appropriate to duplicate stimuli created by construction or remodeling operations. Wood, concrete, a transite simulant, and metal anvils and plates were prepared for use in standardized small-scale sensitivity testing equipment. The materials were coated with a quantifiable amount of contaminant on the testing surface. The materials were then subjected to impact, friction, and ESD sensitivity testing and observed for reactions.

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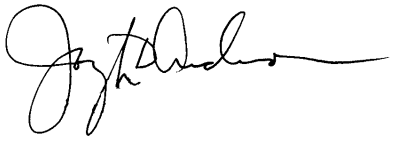
FOREWORD

This report is an adjunct to IHTRs 2269 and 2373, which addressed the explosive contamination levels to which surfaces needed to be cleaned before being released for unrestricted use per DOD Instruction 6055.1. This report also discusses three additional energetic materials: ammonium picrate, nitranol, and nitroglycerin. Also, a new substrate, a transite simulant, was added to the matrix. This report also incorporates the findings from IHTRs 2269 and 2373.

The work reported herein was performed at the Indian Head Division, Naval Surface Warfare Center, Indian Head, MD.



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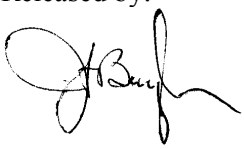

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EXECUTIVE SUMMARY

The purpose of this study is to establish the nonreactivity levels for various explosive substances on wood, steel, transite, and concrete. The nonreactivity level is the maximum concentration of a particular explosive on a surface that does not result in a reaction when tested on a friction, impact, and electro-static discharge machines.

Various concentrations of different explosive substances were placed on surfaces of wood, concrete, transite simulant, and steel and subjected to standard sensitivity tests.

The explosives were ammonium perchlorate, cyclotrimethylenetrinitramine, trinitrotoluene, cyclotetramethylene-tetranitramine, triaminotrinitrobenzene, high bulk-density nitroguanidine, nitrocellulose, trinitrophenylmethylnitramine, ammonium picrate, nitranol, and nitroglycerin.

Testing began at 750 micrograms per square centimeter ($\mu g/cm^2$) contamination levels. This contamination level is easily achieved by conventional cleaning methods. If no reaction was observed at 750 $\mu g/cm^2$, no further testing was performed and 750 $\mu g/cm^2$ was reported as the nonreactivity level.

The nonreactivity levels for friction on transite and wood for all explosives was 750 $\mu g/cm^2$ and also for all explosives on concrete except ammonium perchlorate, cyclotrimethylenetrinitramine and trinitrotoluene, where the nonreactivity level was reached at 200 $\mu g/cm^2$. The nonreactivity level on steel was 500 $\mu g/cm^2$ for ammonium picrate, high bulk-density nitroguanidine, nitrocellulose, nitranol and triamino-trinitrobenzene; 200 $\mu g/cm^2$ for ammonium perchlorate and trinitrotoluene; 100 $\mu g/cm^2$ for cyclotetramethylene-tetranitramine; 75 $\mu g/cm^2$ for cyclotrimethylenetrinitramine and tetryl; and 25 $\mu g/cm^2$ for nitroglycerin.

The nonreactivity levels for impact were established at 750 $\mu g/cm^2$ for all explosives on transite, wood, concrete, and steel except for nitrocellulose (500 $\mu g/cm^2$) and nitroglycerin (25$\mu g/cm^2$), respectively.

Electrostatic discharge testing was only performed on steel surfaces and reactions were observed for all concentrations of explosives.

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DEFINITIONS

ABL	Allegheny Ballistic Laboratories, manufacturers of the friction and electrostatic discharge test equipment.
	Ammonium picrate ($NH_4C_6H_2(NO_2)_3O$). A yellow crystalline compound, highly explosive, Class 1 Division 1 mass detonating explosive.
AP	Ammonium perchlorate (NH_4ClO_4), an oxidizing agent. White crystals in its granular form. When processed to less than 15 microns in size a Class 1 Division 1 (mass detonating) explosive.
cm	Centimeter
ESD	Electrostatic discharge. In reference to test equipment that produces an electrical charge with a fixed voltage and variable capacitance in an electrical circuit.
g	Grams
HBNQ	High bulk-density nitroguanidine ($H_2NC(NH)NHNO_2$). A yellow solid soluble in alcohol. Class 1 Division 1 explosive.
HMX	Cyclotetramethylene-tetranitramine. White crystalline compound. Very powerful explosive, Class 1 Division 1.
J	Joule, a unit of measure for work or energy.
K	Kilo, symbol used to designate a value of 10^3.
L	Liter
μ	Micro, symbol used to designate a value of 10^{-6}.
m	Milli, symbol used to designate a value of 10^{-3}.
mm	Millimeter
NC	Nitrocellulose ($C_6H_7O_5(NO_2)_3$). A cotton-like or pulp-like material of approximately 12.5 to 13.5% nitrogen used for explosives.
NG	Nitroglycerine ($CH_2NO_3CHNO_3CH_2NO_3$). A pale yellow, thick, flammable explosive liquid.
Nitranol	A combination of trimethylolethantrinitrate, triethylene glycol dinitrate, resorcinol, and ethyl centralite.

NOS	Naval Ordnance Station in Indian Head, Maryland, recently renamed as the Indian Head Division, Naval Surface Warfare Center.
RDX	Cyclotrimethylenetrinitramine ($(CH_2)_3N_3(NO_2)_3$). White crystalline compound. Very powerful explosive, Class 1 Division 1.
TATB	Triaminotrinitrobenzene
Tetryl	Common commercial name for trinitrophenylmethylnitramine. Yellow crystalline Class 1 Division 1 explosive.
TNT	Trinitrotoluene ($CH_3C_6H_2(NO_2)_3$). A class 1 Division 1 explosive.
V	Volts

CONTENTS

Tables

Figures

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1.0 BACKGROUND

The downsizing and closing of military facilities has generated the need to eliminate potential explosive hazards from facilities and equipment previously used to process energetic materials. Testing for contamination levels is an established practice; however, there are no established criteria for safe and acceptable levels of contamination of facilities.

Small-scale sensitivity testing was performed to establish levels of contamination with appropriate safety factors that could be shown not to exhibit reactions to normally executed construction practices, such as equipment installation and facility remodeling. Wood, concrete, metal, and transite simulant anvils and plates were prepared for use in the sensitivity testing equipment and then coated with a quantifiable amount of contaminant on the testing surface. These plates and anvils were then subjected to impact, friction, and electrostatic discharge (ESD) sensitivity testing, and observed for reactions to the stimuli.

Two phases of testing have been completed and reported previously. The first phase was documented in Indian Head Technical Report (IHTR) 2269, Naval Surface Warfare Center, 30 June 2000, Sensitivity Testing of Contaminated Surfaces to Establish Nonreactivity Levels of Ammonium Perchlorate, Cyclotrimethylene-trinitramine, and Trinitrotoluene on Wood, Concrete, and Metal and nonreactivity levels were established for these materials on the particular substrates. The report is provided as Appendix A.

The second phase increased the number of contaminants by including HMX, TATB, HBNQ, NC, and tetryl and was reported in IHTR 2373, Naval Surface Warfare Center, 31 Aug 2001, Sensitivity Testing of Contaminated Surfaces to Establish Nonreactivity Levels of HMX, TATB, HBNQ, NC, and Tetryl on Wood, Concrete, and Metal. The report is provided as Appendix B.

This report covers the third phase that is intended to increase the database by adding the contaminants ammonium picrate, nitranol, and nitroglycerin (NG). A new substrate, a transite simulant, was also added to the test matrix. Transite is a common asbestos found in materials in buildings over 30 years old. Because of the hazards associated with asbestos, a simulant was identified whose mechanical properties closely resemble transite. Testing on the transite simulant includes analytes from the previous two phases in addition to the analytes tested in Phase III. The test plan for this third phase can be viewed in Appendix C. Also included in Phase III were uniformity of contamination and control tests. These additional tests were used to determine whether the contamination process created a uniform concentration across the test surface of the friction plates and whether transportation and handling of the plates and anvils affected the concentration of the contaminants on the surface of the substrate.

This report presents the conclusions from the third phase of testing and incorporates the findings from the previous reports into this report.

2.0 TEST DESCRIPTIONS

The following are general descriptions of the preparation and testing performed in the third phase.

2.1 Anvil and Plate Preparation

The contamination area of the friction plate was marked. The entire surface area of the impact and ESD anvils was used. The explosive to be tested was dissolved in an appropriate solvent. The quantity of solution necessary to obtain the desired contamination level was then calculated and this amount placed uniformly over the surface of the test item.

When dry, the test items underwent impact, friction, and ESD testing to determine at what concentration there was a reaction, thus allowing a nonreactivity level to be assigned. The detailed method for spiking plates and anvils can be found in Appendix D.

2.2 Controls

Control plates and anvils were contaminated with various concentrations of contaminants at the same time as the test samples. They accompanied the test samples, but testing was not performed. These controls were then returned to the analytical laboratory to have quantitative analysis performed to check the contamination level. The analysis was to determine whether the degradation of the sample concentration was affected by handling. Additionally, five friction plates were used to validate the uniformity of the contamination, two in the red dye test and three in the mask extraction test. Two metal friction plates were sent to the analytical laboratory to be contaminated at 200µg/cm^2, and 750µg/cm^2 HMX levels. Red dye was added to the solution to help visualize the uniformity of the contaminants. Three metal friction plates were sent to the analytical laboratory to be contaminated with HMX at 50µg/cm^2, 100µg/cm^2, and 500µg/cm^2 levels. These plates were then tested for uniformity of contamination in different areas of the plate. A mask consisting of five 1/2-inch circles were placed on the plates and the contamination contained in the circle was removed from each test circle using swabs saturated with acetonitrile, a solvent capable of removing the HMX. The extractions were then analyzed for contaminant concentration. The result of extractions from the five different locations on each plate was then compared to determine uniformity. The extraction and analysis methods for the control plates can be found in Appendix E.

2.3 Impact, Friction, and ESD Testing

When contaminated with the appropriate contaminant at the proper level on the assigned substrate, the samples were sent to the sensitivity laboratory to undergo impact, friction and ESD testing. Testing set up and methodology can be found in Appendix F.

3.0 DISCUSSION OF RESULTS

The results presented here include the information gathered and previously reported in IHTRs 2269 and 2373, which are included as Appendices A and B, Phases 1 and 2, as well as the results from Phase 3. The test results from Phase 3 can be found in Appendix F.

Testing was started at 750 μg/cm^2 contamination levels. This level is easily achieved by conventional cleaning methods. If no reaction was seen at 750 μg/cm^2, no further testing was performed and 750 μg/cm^2 was reported as the nonreactivity level.

3.1 Friction Test

The nonreactivity values for the friction tests are summarized in Table I. These are the highest concentrations tested that did not have a reaction.

Table I. Nonreactivity Levels for Friction Tests

Substrate contaminant	On steel concentration (μg/cm^2)	On transite concentration (μg/cm^2)	On wood concentration (μg/cm^2)	On concrete concentration (μg/cm^2)
Ammonium picrate	500	750	750	750
AP	200	750	750	200
HBNQ	500	750	750	750
HMX	750	750	750	750
NC	500	750	750	750
NG	25	750	750	750
Nitranol	500	750	750	750
RDX	750	750	750	200
TATB	500	750	750	750
TETRYL	750	750	750	750
TNT	200	750	750	200

3.2 Impact test

The nonreactivity levels for the impact test are shown in Table II. The nonreactivity level is the highest concentration that did not achieve a reaction when subjected to the impact test. The only reactions that occurred during impact testing were with NC on steel at the 750 μg/cm^2 level and NG on steel at the 50 μg/cm^2 level.

Table II. Nonreactivity Levels for Impact

Substrate contaminant	On steel concentration ($\mu g/cm^2$)	On transite concentration ($\mu g/cm^2$)	On wood concentration ($\mu g/cm^2$)	On concrete concentration ($\mu g/cm^2$)
Ammonium picrate	500	750	750	750
AP	750	750	750	750
HBNQ	750	750	750	750
HMX	750	750	750	750
NC	500	750	750	750
NG	25	500	750	750
Nitranol	500	750	750	750
RDX	500	750	750	750
TATB	750	750	750	750
TETRYL	750	750	750	750
TNT	750	750	750	750

3.3 ESD Test Results

Table III contains the results of ESD testing. A reaction was observed for every sample at all levels. However, the reactions were localized since the material around the strike zone was consumed but the rest of the sample was intact. For a detailed discussion on this topic, see page 7 of Appendix A (IHTR 2269). In that report, both fired and unfired samples were evaluated by Fourier transform infrared microscopy (FTIR) and scanning electron microscope.

Table III. ESD Test Results

Contaminant	Substrate	Phase I contamination concentration ($\mu g/cm^2$)	Phase II contamination concentration ($\mu g/cm^2$)	Phase III contamination concentration ($\mu g/cm^2$)	Result
Ammonium picrate	Steel			50, 75, 100	Reactions at all levels
AP	Steel	50, 75, 100, 200			Reactions at all levels
HBNQ	Steel		50, 75, 100		Reactions at all levels
HMX	Steel		50, 75, 100		Reactions at all levels
NC	Steel		50, 75, 100		Reactions at all levels
NG	Steel			50, 75, 100	Reactions at all levels
Nitranol	Steel			50, 75, 100	Reactions at all levels
RDX	Steel	50, 75, 100, 200			Reactions at all levels
TATB	Steel		50, 75, 100		Reactions at all levels
TETRYL	Steel		50, 75, 100		Reactions at all levels
TNT	Steel	50, 75, 100, 200			Reactions at all levels

3.4 Controls Test Results

3.4.1 Uniformity, Red Dye Test

The two metal friction plates that were contaminated with red dye and HMX were inspected visually. The plates appeared to have differences in coloration across the plate surface. This observation would tend to indicate a variation in the concentration levels on the surface. Figure 1 shows the contamination process.

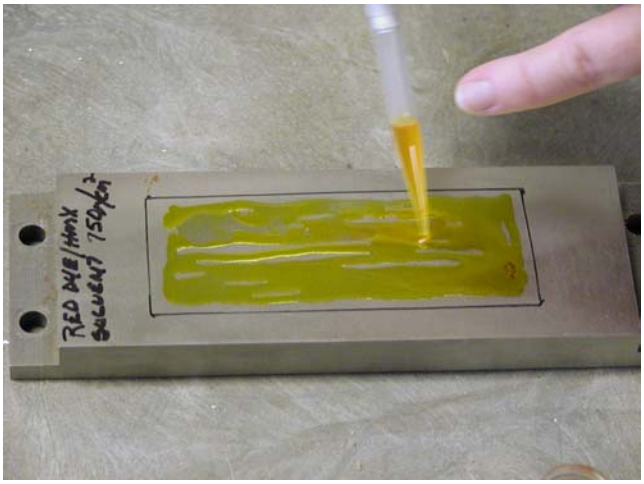

Figure 1. HMX Contamination with Red Dye

3.4.2 Uniformity Mask Extraction Test

The three metal friction plates contaminated with HMX at 50, 100, and 500 µg/cm^2 levels were evaluated for uniformity of contamination. After analysis of the plates, it was observed that they were not contaminated to the stated levels. A review of the calculations performed to determine concentration indicated a mathematical error. Based on the discovery that the masked extraction plates were inaccurately contaminated, new plates and anvils were prepared and the nonreactivity levels from previous testing were validated. All nonreactivity values reported in the tables above were from the new set of data.

A decision was made to continue with the mask extraction test on the original plates. The actual contamination levels on the plates were calculated to be 5.4, 11 and 54 µg/cm^2. Another deviation from the test plan was the number of swabs used to extract the contaminant at each location. The test plan required three swabs, but was changed to four swabs after results of an extraction experiment showed better recovery with four swabs. In addition the acetonitrile saturated swabs were blotted on a clean kimwipe to remove excess solvent prior to use.

The plates were visually inspected and analyzed by imaging software to map the contaminated surface of the plate.

The results of the study showed that the surface area was not uniformly contaminated but rather there were pockets of high concentrations of contaminants along with areas that were not contaminated at levels required. Figure 2 is a diagram showing where the plates were sampled. The sample locations on the plates contaminated at the 11 and 5.4 µg/cm^2 levels are indicated by the red circles. Furthermore, the visible contamination area is outlined in blue. The average value for the 11µg/cm^2 level plate is 16.6 µg/cm^2 with a standard deviation of 3.7. The average value for the 5.4 µg/cm^2 level plate is 7.2 µg/cm^2 with a standard deviation of 2.1.

The detailed report of the uniformity study can be found in Appendix G.

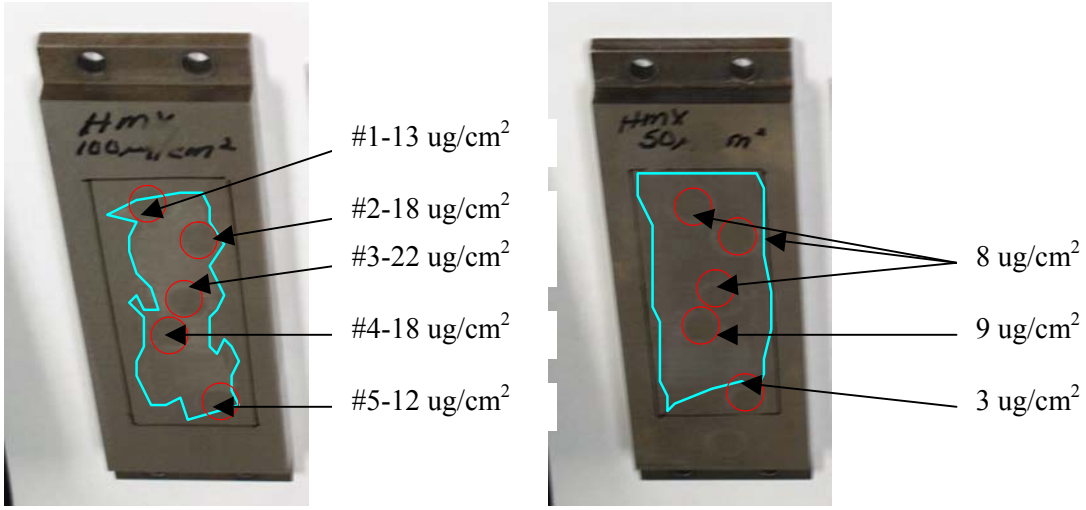

Figure 2. Uniformity Validation Extraction Results

3.4.3 Contamination Recovery Test

Control samples accompanied the test samples to determine whether transportation, or handling had an effect on the concentration of contamination on the plates and anvils. When back in the lab, the test samples were placed in a pan with a particular solvent and gently agitated by hand. Then the explosive was extracted. Table IV shows the contaminant and the solvent used for the extraction. Table V provides the extraction results.

Table IV. Contaminants and Solvents Used for Extraction

Explosive	Solvent	Explosive	Solvent
TATB	Dimethyl-formamide	NC	Tetrahydofuran
AP	Water	HMX	Acetonitrile
Nitranol	Acetonitrile	RDX	Acetonitrile
Picrate	Water	TNT	Acetonitrile
Tetryl	Acetonitrile	HBNQ	Water
NG	Acetonitrile		

Table V. Percent Recovery from Extractions

Explosive	Test material	Spike (ug/cm_2)	Recovery (%)
Tetryl	Cement anvil	200	5
Tetryl	Resin anvil	500	3
Tetryl	Cement plate	500	3
Tetryl	Resin plate	500	6.5
HBNQ	Cement anvil	500	ND
HBNQ	Resin plate	200	15.5
HBNQ	Cement plate	286	ND
AP	Resin plate	750	23
Nitranol	ESD anvil	75	ND
Nitranol	Wood anvil	200	< 5
Nitranol	Resin anvil	500	< 5
Nitranol	Cement anvil	200	< 5
Nitranol	Metal anvil	200	ND
Nitranol	Metal plate	500	ND
Nitranol	Wood plate	500	< 5
Nitranol	Cement plate	500	< 5
Nitranol	Resin plate	500	< 5
NC	Resin plate	750	Interference
NC	Cement plate	750	Interference
NC	Cement anvil	200	Interference
HMX	Cement anvil	750	52
HMX	Cement anvil	500	15
HMX	Cement plate	500	5
HMX	Cement plate	500	18
TNT	Resin plate	200	3
NG	ESD anvil	50	ND
NG	Cement plate	200	1
NG	Wood plate	500	42.4
NG	Metal plate	500	ND
NG	Resin plate	500	ND
NG	Cement plate	500	ND
Explosive D	Wood plate	200	38
Explosive D	Resin plate	200	8.6
Explosive D	Cement plate	200	132
Explosive D	Metal plate	200	12
Explosive D	Resin anvil	200	103
Explosive D	Wood anvil	500	14
Explosive D	Cement anvil	500	65
Explosive D	Metal anvil	200	125

Recovery rates from the control samples were low. One explanation for such recovery rates in the case of wood and concrete, is that the material simply soaked in and would not extract in solution. On the wood friction plates the contaminant can still be observed soaked into the wood.

The control samples were extracted after the entire study was completed. This was several weeks after the initial contamination was performed. In that time, the plates and anvils were moved to various locations for storage. Of the harder, less porous materials, the low extractions could have been the result of the continuous handling knocking off the contaminants and/or evaporation of the subject contaminants due to high volatilities.

A closer look at evaporation rates of the contaminants was performed. NG has a high evaporation rate and it was determined that much of the contamination had evaporated over time, thus giving higher nonreactivity levels than expected. The nonreactivity rate was initially for friction established for NG at 100 ug/cm^2 but after strictly controlling the exposure time of the sample, the nonreactivity level was reduced to 25 ug/cm^2.

4.0 DISCUSSION

Based on the discovery that the masked extraction plates were inaccurately contaminated and on the poor recovery rates from the control samples, new steel plates and steel anvils were prepared. All calculations for the new plates and anvils were checked for accuracy prior to contaminating the anvils and plates. All weight and volumetric data were cross-verified. The nonreactivity levels for the steel substrate from previous testing were all retested and validated. All steel substrate nonreactivity values reported in the tables above were from the new set of data.

Based on data from the uniformity study the samples tested did not contain a uniform concentration of contamination. There were "hot" spots and "cold" spots. This means that some of the friction tests may have occurred in a location of minimal contamination but others had to have occurred in areas of maximum concentration. A look at the picture, Figure 3, shows that the entire area of the plate has been tested in the 20 shots of friction testing and thus the maximum concentration areas were subjected to testing.

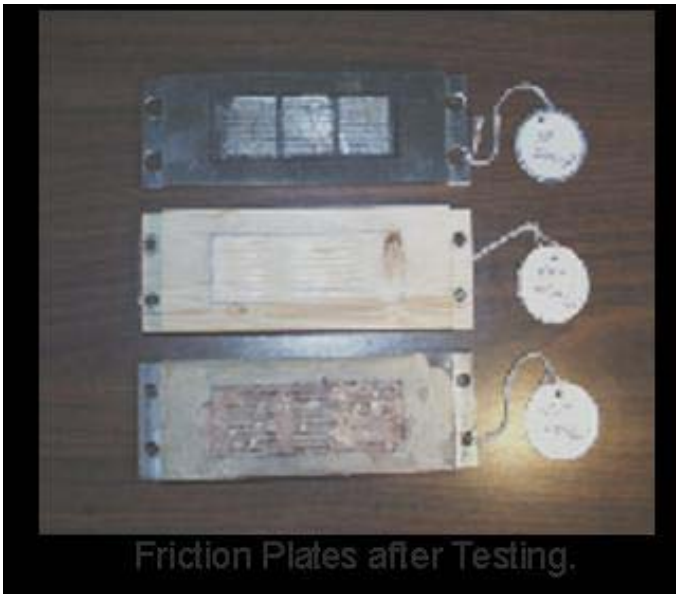

Figure 3. Friction Plates

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Appendix A

IHTR 2269

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Indian Head Division
Naval Surface Warfare Center
Indian Head, MD 20640-5035

IHTR 2269
30 June 2000

SENSITIVITY TESTING OF CONTAMINATED SURFACES TO ESTABLISH NON-REACTIVITY LEVELS OF AMMONIUM PERCHLORATE, CYCLOTRIMETHYLENETRITRAMINE, AND TRINITROTOLUENE ON WOOD, CONCRETE, AND METAL

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13. ABSTRACT (*Maximum 200 words*)

The rightsizing and closing of military establishments have generated the need to eliminate potential explosive hazards from facilities previously used to process energetic materials. Testing for contamination levels is an established practice; however, there are no established criteria for safe levels of contamination of facilities.

Small-scale sensitivity testing was performed to establish levels of contamination that would not exhibit reactions to normally executed construction practices, such as equipment installation and facility remodeling. Standard friction, impact, and electrostatic discharge (ESD) sensitivity tests were selected as appropriate to simulate stimuli created by construction or remodeling operations. Wood, concrete, and metal anvils and plates were prepared for use in standardized small-scale sensitivity testing equipment and then coated with a quantifiable amount of contaminant on the testing surface. These anvils and plates were then subjected to impact, friction, and ESD sensitivity testing and observed for reactions to the stimuli. Results are given.

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FOREWORD

The work reported herein was performed at the Indian Head Division, Naval Surface Warfare Center, Indian Head, MD, as part of our task to accomplish the explosive decontamination of the Naval Weapons Industrial Reserve Plant located in McGregor, Texas.

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Director, Cast Division

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Head, Ordnance Department

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EXECUTIVE SUMMARY

This report documents the efforts pursued to identify levels of contamination in which no detectable evidence of reaction was observed using standard sensitivity testing methodology. The testing is necessary to establish a safe and acceptable level of contamination of facilities previously used to process and manufacture pyrotechnics, explosives, and propellants.

Standardized small-scale sensitivity tests—impact, friction, and electrostatic discharge—were conducted on contaminated surfaces. Wood, concrete, and metal surfaces were contaminated with ammonium perchlorate (AP), cyclotrimethylenetrinitramine (RDX), and trinitrotoluene (TNT) at quantifiable levels and observed for reactions to the testing stimuli.

Impact testing reached the 500-μg/cm^2 contamination level with no reactions for all testing surfaces with the three contaminants.

Friction testing reached the 500-μg/cm^2 contamination level with no reactions for wood surfaces for the three contaminants. Testing was not performed at higher levels for the impact and the wood surface friction tests because conventional decontamination efforts can easily achieve these levels.

Friction testing produced reactions at the 500-μg/cm^2 contamination level for AP-, RDX-, and TNT-contaminated concrete and AP- and TNT-contaminated metal surfaces. No reactions were observed at the 200-μg/cm^2 contamination level for these surfaces.

Friction testing produced reactions at the 100-μg/cm^2 contamination level for the RDX-contaminated metal surface. No reactions were observed at the 75-μg/cm^2 contamination level for this surface.

Testing performed was unable to determine a non-reactivity level for electrostatic discharge stimuli. Reactions were observed at all levels of contamination submitted for testing, the lowest level being 50 μg/cm^2. The stimuli applied appeared to have caused a localized reaction but was unable to sustain a reaction throughout the entire sample of contaminant. Quantitative analysis performed on the anvils that produced the positive reactions recorded varying amounts of contaminants remaining on the testing surface.

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DEFINITIONS

ABL	Alleghany Ballistic Laboratories, a subsidiary of Hercules Incorporated. Manufacturers of the friction and electrostatic discharge test equipment.
AP	Ammonium perchlorate (NH_4ClO_4). An oxidizing agent. White crystals in its granular form. When processed to less than 15 microns in size, a Class 1 Division 1 (mass detonating) explosive.
cm	Centimeter.
RDX	Cyclotrimethylenetrinitramine ($(CH_2)_3N_3(NO_2)_3$). White crystalline compound. Very powerful explosive, Class 1 Division 1.
ESD	Electrostatic discharge. In reference to test equipment that produces an electrical charge with a fixed voltage and variable capacitance in an electrical circuit.
g	Grams.
J	Joule, a unit of measure for work or energy.
K	Symbol used to designate a value of 10^3.
L	Liter.
μ	Symbol used to designate a value of 10^{-6}.
m	Symbol used to designate a value of 10^{-3}.
mm	Millimeter.
NOS	Naval Ordnance Station in Indian Head, Maryland, recently renamed as Naval Surface Warfare Center, Indian Head Division.
TNT	Trinitrotoluene ($CH_3C_6H_2(NO_2)_3$). High explosive.
V	Volts.

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CONTENTS

Tables

Figures

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BACKGROUND

The downsizing and closing of military establishments have generated the need to eliminate potential hazards from facilities previously used to process energetic materials. Testing for contamination levels is an established practice; however, there are no established criteria for safe and acceptable levels of contamination of facilities.

To establish levels of contamination with appropriate safety factors that could be shown not to exhibit reactions to normally executed construction practices, such as equipment installation and facility remodeling, small-scale sensitivity testing was performed. Wood, concrete, and metal anvils and plates were prepared for use in the sensitivity testing equipment and then coated with a quantifiable amount of contaminant on the testing surface. These plates and anvils were then subjected to impact, friction, and electrostatic discharge (ESD) sensitivity testing and observed for reactions to the stimuli.

TEST SURFACE PREPARATION

Manufacturing drawings of the impact anvil and friction plate specified for the NOS impact and ABL friction test equipment were obtained. The metal anvils and plates were prepared per the drawing specifications (Hercules Incorporated drawing numbers SE-SK 3810 and F255-0202 respectively). The wood anvils and plates were prepared with dimensions consistent with the drawings. Figure 1 shows the wooden and metal impact anvils prior to contamination and testing. Figure 2 shows the metal and wooden friction plates prior to contamination and testing.

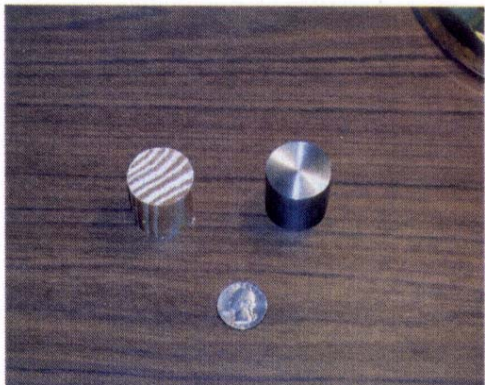

Figure 1. Wood and Metal Impact Anvils

Figure 2. Wood and Metal Friction Plates

For the concrete plates and anvils, a metal shell was manufactured with overall dimensions consistent with the manufacturing drawings, then filled with concrete to provide the concrete testing surface. Figure 3 shows the empty metal shells for the friction plate and impact anvils. Figure 4 shows the metal shells filled with concrete prior to contamination and testing.

Figure 3. Metal Shells for Concrete Friction Plate and Impact Anvil

Figure 4. Concrete Friction Plate and Impact Anvil

No manufacturing drawing exists for the anvils used in the ABL ESD tester. The testing surface is the top of a 1/4-inch-diameter cylinder protruding from a base plate, which provides the path to ground for the electrical discharge. Figure 5 is a drawing of the anvil with the testing surface indicated. With advice from sensitivity testing laboratory personnel and machining experts, a base plate was produced with dimensions consistent with an existing anvil and a blind hole to facilitate inserts. The inserts were precisely machined to provide maximum contact surface area with the base plate. Figure 6 shows the base plate and inserts arranged in a holder prepared to be contaminated. Wood and concrete lack the ability to effectively conduct an electrostatic charge. Without a path to ground, the charge will not pass through the contaminant on the testing surface and no reactions would occur at any contamination level. Therefore, only metal inserts were prepared for the ESD testing.

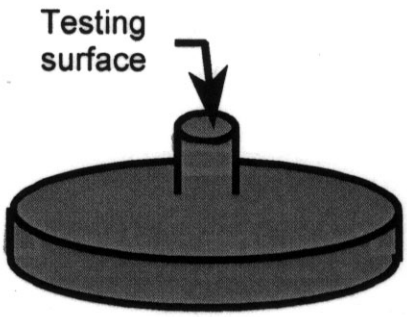

Figure 5. Anvil Used on Electrostatic Discharge Tester

Figure 6. Electrostatic Discharge Base Plate and Inserts

Surface Contamination

Contamination of the testing surfaces was performed by the Applied Analytical Laboratory, Code 330, of the Test and Evaluation Department, Naval Surface Warfare Center, Indian Head Division. The contaminants were deposited on the testing surfaces by drop-wise addition of a standard solution of the materials. Figure 7 shows laboratory personnel applying the calculated amount of standard solution to the ESD inserts with a graduated pipette. For example, the laboratory standard solution for cyclotrimethylenetrinitramine (RDX) is at a concentration of 1.611 mg/mL. The following is a sample math calculation used to determine how much of the standard solution is applied on an electrostatic anvil to achieve a contamination level of 75 $\mu g/cm^2$:

$A_{anvil} = \pi r^2 = (3.14159)(0.3175cm)^2 = 0.317\ cm^2$
Amount of contaminant required $\Rightarrow (75\ \mu g/cm^2)(0.317\ cm^2) = 23.8\ \mu g$
Amount of standard solution required (X) $\Rightarrow (\mu L/1.611\ \mu g) = (X/23.8\ \mu g)$
$X = (23.8\ g/1.611\ \mu g)\mu L$
$X = 14.77\ \mu L$

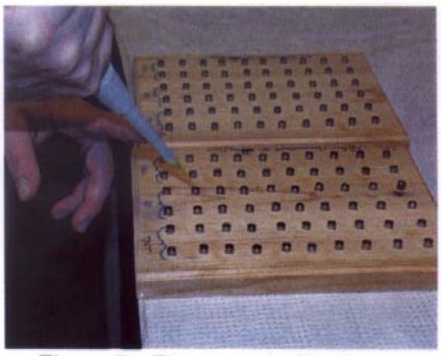

Figure 7. Electrostatic Discharge Anvils Being Contaminated

To ensure the absence of breakdown products, artifacts of manufacture, or other impurities that could affect the results of sensitivity testing, solutions of the contaminants were composed using ultra-pure reference materials.

All the plates and anvils were labeled with a contaminant identifier and the level of contamination. The sets of plates and anvils were packaged to ensure there was no contact between the testing surfaces and other surfaces. Although trinitrotoluene (TNT) breakdown at ambient conditions should be minimal, the set contaminated with TNT was boxed separately and the container purged with nitrogen and sealed to prevent possible auto-oxidative or photolytic breakdown prior to testing.

The first set of plates and anvils were contaminated to a level of 200 μg/cm^2. This translates to a total of 7 mg of contaminant spread equally over an area of 10 by 3.5 cm on the friction plates. The area of interest on the friction plate was marked to ensure that the material was deposited as evenly as possible in the defined area and that the testing would also be confined to the contaminated surface. A total of 1.5 mg and 0.06 mg of contaminant was deposited over the entire top surface of the impact and electrostatic anvils, respectively, to attain the contamination level of 200 μg/cm^2. Levels of contamination were then either raised or lowered depending on the testing results of the 200-μg/cm^2 contamination level. Table I lists all levels of contamination used and the amounts applied to the different testing surfaces to attain the specific level of contamination.

Table I. Contaminant Amount Applied to Testing Surfaces

Contamination level (μg/cm^2)	Impact anvils (surface area = 7.54 cm^2) (mg)	Friction plates (surface area=35 cm^2) (mg)	Electrostatic discharge anvils (surface area=0.317 cm^2) (mg)
500	3.5	17.5	Not tested at this level
200	1.4	7	0.063
150	Not tested at this level	5.25	Not tested at this level
100	Not tested at this level	3.5	0.0315
75	Not tested at this level	2.63	0.024
50	Not tested at this level	1.75	0.016

TEST DESCRIPTIONS AND RESULTS

Small-scale safety testing was performed on the wood, concrete, and metal anvils and plates contaminated with ammonium perchlorate (AP), RDX, and TNT by the Explosives and Propellants Division, Code 940, of the Patterson Laboratory and Pilot Plant, Indian Head Division. Three tests were performed: the NOS impact test; the ABL friction test; and the ABL ESD test. Descriptions of the equipment and specifics about the testing methods are given in Appendix A.

NOS Impact Test

NOS impact testing was conducted on impact anvils (wood, concrete, and metal) contaminated at the 200- and 500-μg/cm^2 levels. A drop height of 1,000 mm (maximum height available on the NOS impact tester) with a 5-kg drop weight was used for all anvils. The collision between the 5-kg weight and the anvil was observed for any signs that the contaminant initiated, such as smoke, spark, flame, or odor. If any one of these signs was observed, a reaction (or fire) would be annotated on the test worksheets. Each anvil was subjected to ten drops of the 5-kg weight. No positive reactions were observed for any material at any contamination level. The worksheets with raw test data for the impact testing are in Appendix B. Higher levels of contamination for impact testing were not pursued because conventional cleaning techniques can easily achieve levels of 500 μg/cm^2 or lower. Figure 8 displays three of the 500-μg/cm^2 contaminated impact anvils after testing was completed.

Figure 8. Impact Anvils After Testing

ABL Friction Test

ABL friction testing was conducted on friction plates (wood, concrete, and metal) starting at a contamination level of 200 μg/cm^2 for all three contaminants. The friction tester moves the plate under a 1-inch steel wheel that slides across the plate with a variable pressure level. The speed at which the plate moves under the wheel is also variable, but the standard speed (8 ft/s) was used for all the friction plates. The pressure between the friction wheel and the plate was set at the highest possible level (980 psig) for the metal friction plates. The pressure used for the concrete plates was varied to prevent the concrete from being destroyed. Due to the softness of the wood, a maximum pressure of 180 psig was used on those plates to keep the friction wheel from sinking too far into the wood. The interaction between the wheel and the plate was observed for any signs that the contaminant initiated, such as smoke, spark, flame, or odor. If any one of these signs was observed, a reaction (or fire) would be annotated on the test worksheets. Figure 9 shows three of the friction plates after testing.

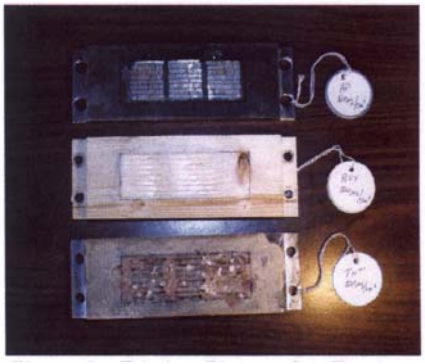

Figure 9. Friction Plates After Testing

Contaminated Wood Friction Plates: The wood friction plates contaminated with AP, RDX, and TNT were tested at the 200- and 500-μg/cm^2 levels of contamination. There were no reactions observed with the contaminants on the wood friction plates at either level. The worksheets with raw test data sheets for the wood friction plates can be reviewed in Appendix C.

AP-Contaminated Concrete and Metal Friction Plates: The AP-contaminated concrete and metal friction plates did not display any reactions at the 200-μg/cm^2 level, but positive reactions were observed at the 500-μg/cm^2 contamination level. The worksheets with raw test data for the AP-contaminated concrete and metal friction plates can be reviewed in Appendix D.

RDX-Contaminated Concrete and Metal Friction Plates: The RDX-contaminated concrete friction plate did not display any reaction at the 200-μg/cm^2 level, but positive reactions were observed at the 500-μg/cm^2 level. No iterations were done to pinpoint the maximum contamination level with no positive reaction for the RDX-contaminated concrete friction plate. At the 200-μg/cm^2 contamination level the only friction plate to show a positive reaction was the metal plate contaminated with RDX. Thus, the RDX level of contamination for metal was reduced and retested at 150, 100, 75, and 50 μg/cm^2. Positive reactions were observed at the 150- and 100-μg/cm^2 levels of RDX contamination, but no reaction were observed at the 75- or 50-μg/cm^2 levels. The worksheets with raw test data for the friction testing of RDX-contaminated concrete and metal friction plates can be reviewed in Appendix E.

TNT-Contaminated Concrete and Metal Friction Plates: The TNT-contaminated concrete and metal friction plates did not display any reactions at the 200-μg/cm^2 level, but positive reactions were observed at the 500-μg/cm^2 contamination level. The worksheets with raw test data for the TNT-contaminated concrete and metal friction plates can be reviewed in Appendix F.

Electrostatic Discharge Test

Electrostatic discharge testing was performed on the ABL Model 150 ESD tester using the base plate and metal insert anvil described above. Figure 10 shows the assembled base plate and insert installed in the ESD tester. A fixed voltage of 5.785 kV was applied to the testing surface. The highest available capacitance of 8.33 J was used to complete the circuit. The anvil testing surface was observed for any indications that the contaminant has initiated, i.e., any signs of spark, smoke, flame, or odor. If any of these signs were observed, it was considered a reaction and was annotated as such on the test worksheets.

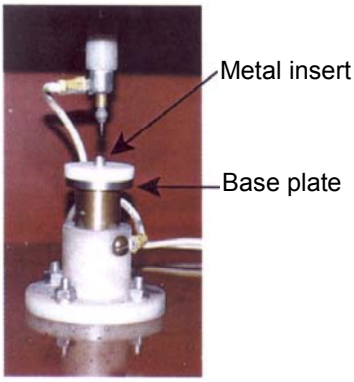

Figure 10. Electrostatic Anvil in Tester

At the 200-µg/cm^2 Contamination Level: The AP-contaminated anvils had four no-reaction shots before a positive reaction was observed. The RDX-contaminated anvils had five no-reaction shots before a positive reaction was observed. The TNT-contaminated anvils had one no-reaction shot before a positive reaction was observed. The worksheets with raw test data for the ESD testing are in Appendix G.

At the 100-µg/cm^2 Contamination Level: The AP-contaminated anvils had ten no-reaction shots before a positive reaction was observed. The RDX-contaminated anvils had three no-reaction shots before a positive reaction was observed. The TNT-contaminated anvils had five no-reaction shots before a positive reaction was observed. The worksheets with raw test data for the ESD testing are in Appendix H.

At the 75-µg/cm^2 Contamination Level: The AP-contaminated anvils had zero no-reaction shots before a positive reaction was observed as did the RDX-contaminated anvils. The TNT-contaminated anvils had six no-reaction shots before a positive reaction was observed. The worksheets with raw test data are in Appendix I.

At the 50-µg/cm^2 Contamination Level: The AP- and RDX-contaminated anvils had three no-reaction shots before a positive reaction was observed. The TNT-contaminated anvils had zero no-reaction shots before a positive reaction was observed. The worksheets with raw test data are in Appendix J.

Characterization of Residue on ESD Anvils

Both fired and unfired ESD anvils were evaluated by Fourier transform infrared (FTIR) microscopy and scanning electron microscopy to obtain a record of the condition of the surfaces before any destructive analyses were performed. Appendix K contains the scanning electron micrographs of all surfaces analyzed by FTIR. It was observed by the laboratory personnel that material that appeared unburned remained on all fired anvils.

The residual RDX and TNT on the anvils were quantitatively analyzed for the weight of energetic material present on the testing surface by high performance liquid chromatography and the residual AP by ion chromatography. No significance decrease was seen in the relative amounts of TNT in the fired versus unfired anvils. The amounts of RDX and AP recovered from the surfaces of the fired anvils varied. However, it is important to note that RDX, TNT, and AP remained on all fired anvils. See Appendix L for the test data on amounts of energetic material recovered from both fired and unfired anvils.

CONCLUSIONS

Impact testing reached the 500-μg/cm^2 contamination level with no reactions for all testing surfaces with the three contaminants.

Friction testing reached the 500-μg/cm^2 contamination level with no reactions for wood surfaces for the three contaminants. Testing was not performed at higher levels for the impact and the wood surface friction tests because conventional decontamination efforts can easily achieve these levels.

Friction testing produced reactions at the 500-μg/cm^2 contamination level for AP-, RDX-, and TNT-contaminated concrete and AP- and TNT-contaminated metal surfaces. No reactions were observed at the 200-μg/cm^2 contamination level for these surfaces.

Friction testing produced reactions at the 100-μg/cm^2 contamination level for the RDX-contaminated metal surface. No reactions were observed at the 75-μg/cm^2 contamination level for this surface.

Testing performed was unable to determine a non-reactivity level for ESD stimuli. Reactions were observed at all levels of contamination submitted for testing, the lowest level being 50 μg/cm^2. The stimuli applied appeared to have caused a localized reaction but was unable to sustain a reaction throughout the entire sample of contaminant. Quantitative analysis performed on the anvils that produced the positive reactions recorded varying amounts of contaminants remaining on the testing surface.

Appendix A

SMALL-SCALE SAFETY TESTS

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Small Scale Safety Tests

Naval Surface Warfare Center, Indian Head Division

Sponsored by

Explosives and Propellants Division Code 940, Patterson Laboratory & Pilot Plant

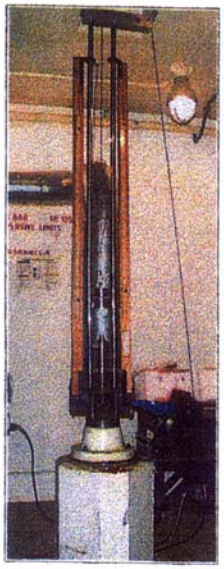
Instructors:

Philip Thomas
Daniel Remmers

Purpose of Safety Testing

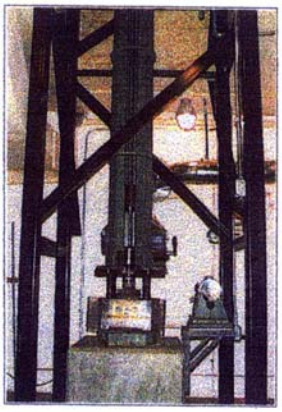
- To provide information about the relative hazards of a material before further work is done.
- To provide information that can be used to generate handling and processing requirements.
- To obtain an official Interim Hazard Classification (IHC) and Storage Compatibility Code.

IMPACT TESTS

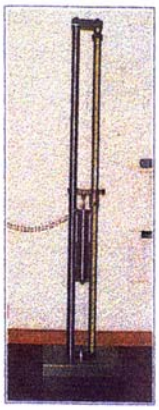


NOS Impact Test: This tester uses a 5 kg weight and type 12 tools. The Bruceton up and down method is employed, yielding a 50% drop height in millimeters. A total of 25 drops are used for each test, and sample size is 35 mg per drop.

ERL Bruceton Impact Test: This tester was developed in the 1940s. It uses a 2.5 kg weight and type 12 tools. All samples, except for those containing AP, are placed on sandpaper for testing. A total of 25 drops are used for each test, and sample size is 35 mg per drop. A noise meter determines a positive or negative result. The 50% drop height is given in centimeters.



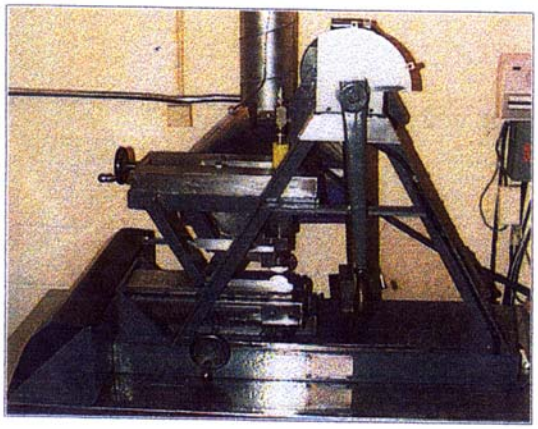
BOE Impact Test: The Bureau of Explosives impact test is required for DOT classification. A total of 10 drops are used per test, and samples are 10 mg in size. The drop height for solids is 4 inches, and the drop height for liquids is 10 inches. A sample must have less than 5 positives at the set level in order to pass the test.



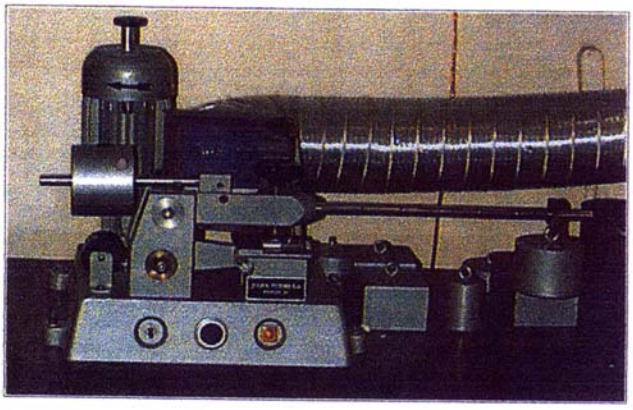
BIC Test: The Ballistic Impact Chamber test uses a closed chamber of fixed volume and records the pressure vs. time curve on an oscilloscope as the sample reacts. This is a research tool which can determine shock sensitivity.

FRICTION TESTS

ABL Friction Test: This tester uses a steel wheel sliding 1" across the sample on a steel plate. The pressure between the wheel and plate is varied, using 13 levels between 30 and 1000 psig, and the threshold initiation level (TIL) is determined. The threshold initiation level is the level at which 20 negatives are observed with at least one positive at the next higher level. The speed of the plate can be varied from 8 ft/sec to 1 ft/sec, however the standard speed is 8 ft/sec. Sample size is 35-45 mg per trial.



BAM Friction Test: This tester is from Germany (BAM stands for "Bundesanstalt fur Material Prufung") and is the NATO standard friction test. It uses a porcelain peg sliding back and forth 1 cm across the sample on a porcelain plate. The force between the peg and plate is varied between 6 and 360 newtons, resulting in a TIL value with 10 negatives. Sample size is 35-45 mg per trial.

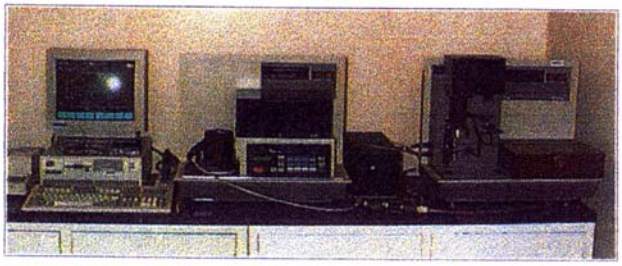


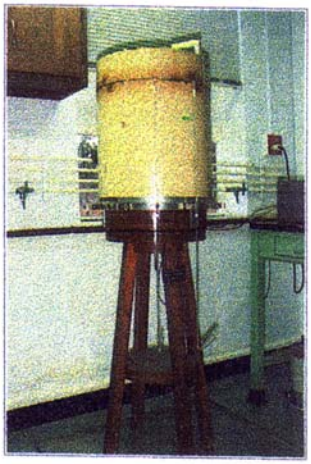
ELECTROSTATIC DISCHARGE TEST

The **ABL Electrostatic Discharge** test employs an approaching gap electrode with a fixed voltage of 5.785 kV and a variable capacitance. The 20 TIL value is determined, ranging from 0.0084 to 8.33 joules. Sample size is 35-45 mg per trial.

THERMAL TESTS

DSC & TGA: The Differential Scanning Calorimetry and Thermo-Gravimetric Analysis tests use a very small sample, 5 mg or less, and a programmable heating method capable of temperatures ranging from ambient to 500°C. The DSC measures heat flow (endotherms and exotherms), and the TGA measures weight loss.





VTS: The Vacuum Thermal Stability test subjects a 0.2 gram sample to 100°C for 48 hours under vacuum. The gas evolved is measured via a mercury column, and is given in cm^3/gram/hour. The temperature and heating time can be varied for non-standard tests.

SENSITIVITY RANGES

TEST	HIGH	MEDIUM	LOW
IMPACT:			
NOS impact, 50% height (mm)	13 - 63	63 - 398	398 - 1000
WO impact, 50% height (cm) (ERL Bruceton machine)	5 - 15	15 - 100	100 - 320
SLIDING FRICTION:			
ABL friction, 20 TIL (psig)	30 or less	40 - 420	560 - 1000
BAM friction, 10 TIL (newtons)	6 - 54	60 - 144	160-360
ELECTROSTATIC DISCHARGE:			
ABL ESD, 20 TIL (joules)	0.0084 - 0.023	0.037 - 0.853	1.72 - 8.33

NOTE: The TIL (Threshold Initiation Level) is the level at which 10 or 20 negatives are observed with at least one positive at the next higher level.

SAFETY TEST DATA

material	NOS Impact 50% height (mm)	WO Impact 50% height (cm)	ABL Friction 20 TIL (psig)	BAM Friction 10 TIL (newtons)	ESD 20 TIL (joules)	VTS 100°C, 48 hrs (cc/g)
ZIRCONIUM	>1000	>320	<30	-	<0.0084	-
RDX	163-263	18-21	180-420	84-144	0.037-0.165	0.19
HMX	89-119	19-25	-	72-96	0.095-0.165	0.12
PETN	157-162	10-14	<30	36-56	0.023-0.326	0.80
CL-20	31-81	7-12	<30-40	48-72	0.037-1.72	-
PBXN-103	61	13 (bare tools)	<30	16	>8.33	1.57
PBXN-110	198	35	-	-	4.20	0.12
PLG/UW-13	68-99	15 (bare tools)	<30	16-24	0.853	0.84
LOVA	230-280	-	>980	>360	0.853	-
COMP A-5	287	23	560	-	0.853	0.12
PBXN-301	492	16	75	36	1.72	0.21

Important Issues
for Small Scale Safety Tests

- Data must be compared to that of known standards--preferably tested under the same conditions.
- Small sample sizes provide only moderate reproducibility.
- Tests do not indicate how larger samples will react under the same conditions.
- Test results only assess the onset stimuli, not the severity of the reaction.
- Tests do not determine whether a detonation will occur--you should assume it will.

Appendix B

NOS IMPACT TEST RESULTS

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NOS IMPACT TEST

sample name: AP contaminated wood
sample ID: 200µg/cm²
sample prep: residue
requester: Anne Caris, 2150K
operator: P. Thomas/T. Woodland

date: 6/7/99
temperature: 19 °C
relative humidity: 48 %
surface: bare tools

	height (mm)	result	comments
pre-shots -->	251	0	no reaction
	501	0	no reaction
	794	0	no reaction
	1000	0	no reaction

NOS Impact tester
with type 12 tools,
5 kg drop weight,
building 888, room 105

shot #	height (mm)	result	comments
1	1000	0	
2	1000	0	
3	1000	0	
4	1000	0	
5	1000	0	
6	1000	0	
7	1000	0	
8	1000	0	
9	1000	0	
10	1000	0	
11	1000		
12	0		no reactions
13	0		
14	0		
15	0		
16	0		
17	0		
18	0		
19	0		
20	0		
21	0		
22	0		
23	0		
24	0		
25	0		

available levels (mm)	log heights
1000	3.0
794	2.9
631	2.8
501	2.7
398	2.6
316	2.5
251	2.4
200	2.3
158	2.2
126	2.1
100	2.0
79	1.9
63	1.8
50	1.7
40	1.6
32	1.5
25	1.4
20	1.3
16	1.2
13	1.1

1 = positive (fire)
0 = negative (no-fire)

50% height	standard deviation
>1000 mm	— log units

NOS IMPACT TEST

sample name: AP contaminated concrete
sample ID: 200µg/cm 2
sample prep: residue
requester: Anne Caris, 2150K
operator: P. Thomas/T. Woodland

date: 6/7/99
temperature: 19 °C
relative humidity: 48 %
surface: bare tools

	height (mm)	result	comments
pre-shots -->	251	0	no reaction
	501	0	no reaction
	794	0	no reaction
	1000	0	no reaction

NOS Impact tester
with type 12 tools,
5 kg drop weight,
building 888, room 105

shot #	height (mm)	result	comments
1	1000	0	
2	1000	0	
3	1000	0	
4	1000	0	
5	1000	0	
6	1000	0	
7	1000	0	
8	1000	0	
9	1000	0	
10	1000	0	
11	1000		
12	0		no reactions
13	0		
14	0		
15	0		
16	0		
17	0		
18	0		
19	0		
20	0		
21	0		
22	0		
23	0		
24	0		
25	0		

available levels (mm)	log heights
1000	3.0
794	2.9
631	2.8
501	2.7
398	2.6
316	2.5
251	2.4
200	2.3
158	2.2
126	2.1
100	2.0
79	1.9
63	1.8
50	1.7
40	1.6
32	1.5
25	1.4
20	1.3
16	1.2
13	1.1

1 = positive (fire)
0 = negative (no-fire)

50% height	standard deviation
>1000 mm	-- log units

NOS IMPACT TEST

sample name: AP contaminated steel
sample ID: 200µg/cm 2
sample prep: residue
requester: Anne Caris, 2150K
operator: P. Thomas/T. Woodland

date: 6/7/99
temperature: 19 °C
relative humidity: 48 %
surface: bare tools

	height (mm)	result	comments
pre-shots -->	1000	0	no reaction

NOS Impact tester
with type 12 tools,
5 kg drop weight,
building 888, room 105

shot #	height (mm)	result	comments
1	1000	0	
2	1000	0	
3	1000	0	
4	1000	0	
5	1000	0	
6	1000	0	
7	1000	0	
8	1000	0	
9	1000	0	
10	1000	0	
11	1000		
12	0		no reactions
13	0		
14	0		
15	0		
16	0		
17	0		
18	0		
19	0		
20	0		
21	0		
22	0		
23	0		
24	0		
25	0		

available levels (mm)	log heights
1000	3.0
794	2.9
631	2.8
501	2.7
398	2.6
316	2.5
251	2.4
200	2.3
158	2.2
126	2.1
100	2.0
79	1.9
63	1.8
50	1.7
40	1.6
32	1.5
25	1.4
20	1.3
16	1.2
13	1.1

1 = positive (fire)
0 = negative (no-fire)

50% height	standard deviation
>1000 mm	-- log units

NOS IMPACT TEST

sample name: RDX contaminated wood
sample ID: 200µg/cm²
sample prep: residue
requester: Anne Caris, 2150K
operator: P. Thomas/T. Woodland

date: 6/7/99
temperature: 19 °C
relative humidity: 48 %
surface: bare tools

	height (mm)	result	comments
pre-shots -->	251	0	no reaction
	501	0	no reaction
	794	0	no reaction
	1000	0	no reaction

NOS Impact tester
with type 12 tools,
5 kg drop weight,
building 888, room 105

shot #	height (mm)	result	comments
1	1000	0	
2	1000	0	
3	1000	0	
4	1000	0	
5	1000	0	
6	1000	0	
7	1000	0	
8	1000	0	
9	1000	0	
10	1000	0	
11	1000		
12	0		no reactions
13	0		
14	0		
15	0		
16	0		
17	0		
18	0		
19	0		
20	0		
21	0		
22	0		
23	0		
24	0		
25	0		

available levels (mm)	log heights
1000	3.0
794	2.9
631	2.8
501	2.7
398	2.6
316	2.5
251	2.4
200	2.3
158	2.2
126	2.1
100	2.0
79	1.9
63	1.8
50	1.7
40	1.6
32	1.5
25	1.4
20	1.3
16	1.2
13	1.1

1 = positive (fire)
0 = negative (no-fire)

50% height	standard deviation
>1000 mm	— log units

NOS IMPACT TEST

sample name: RDX contaminated concrete
sample ID: 200µg/cm²
sample prep: residue
requester: Anne Caris, 2150K
operator: P. Thomas/T. Woodland

date: 6/7/99
temperature: 19 °C
relative humidity: 48 %
surface: bare tools

	height (mm)	result	comments
pre-shots -->	251	0	no reaction
	501	0	no reaction
	794	0	no reaction
	1000	0	no reaction

NOS Impact tester
with type 12 tools,
5 kg drop weight,
building 888, room 105

shot #	height (mm)	result	comments
1	1000	0	
2	1000	0	
3	1000	0	
4	1000	0	
5	1000	0	
6	1000	0	
7	1000	0	
8	1000	0	
9	1000	0	
10	1000	0	
11	1000		
12	0		no reactions
13	0		
14	0		
15	0		
16	0		
17	0		
18	0		
19	0		
20	0		
21	0		
22	0		
23	0		
24	0		
25	0		

available levels (mm)	log heights
1000	3.0
794	2.9
631	2.8
501	2.7
398	2.6
316	2.5
251	2.4
200	2.3
158	2.2
126	2.1
100	2.0
79	1.9
63	1.8
50	1.7
40	1.6
32	1.5
25	1.4
20	1.3
16	1.2
13	1.1

1 = positive (fire)
0 = negative (no-fire)

50% height	standard deviation
>1000 mm	-- log units

NOS IMPACT TEST

sample name: RDX contaminated steel
sample ID: 200µg/cm²
sample prep: residue
requester: Anne Caris, 2150K
operator: P. Thomas/T. Woodland

date: 6/7/99
temperature: 19 °C
relative humidity: 48 %
surface: bare tools

	height (mm)	result	comments
pre-shots -->	1000	0	no reaction

NOS Impact tester
with type 12 tools,
5 kg drop weight,
35 mg per drop,
building 888, room 105

shot #	height (mm)	result	comments
1	1000	0	
2	1000	0	
3	1000	0	
4	1000	0	
5	1000	0	
6	1000	0	
7	1000	0	
8	1000	0	
9	1000	0	
10	1000	0	
11	1000		
12	0		no reactions
13	0		
14	0		
15	0		
16	0		
17	0		
18	0		
19	0		
20	0		
21	0		
22	0		
23	0		
24	0		
25	0		

available levels (mm)	log heights
1000	3.0
794	2.9
631	2.8
501	2.7
398	2.6
316	2.5
251	2.4
200	2.3
158	2.2
126	2.1
100	2.0
79	1.9
63	1.8
50	1.7
40	1.6
32	1.5
25	1.4
20	1.3
16	1.2
13	1.1

1 = positive (fire)
0 = negative (no-fire)

50% height	standard deviation
>1000 mm	— log units

NOS IMPACT TEST

sample name: TNT contaminated wood
sample ID: 200µg/cm²
sample prep: residue
requester: Anne Caris, 2150K
operator: P. Thomas/T. Woodland

date: 6/8/99
temperature: 19 °C
relative humidity: 48 %
surface: bare tools

	height (mm)	result	comments
pre-shots -->	251	0	no reaction
	501	0	no reaction
	794	0	no reaction
	1000	0	no reaction

NOS Impact tester
with type 12 tools,
5 kg drop weight,
building 888, room 105

shot #	height (mm)	result	comments
1	1000	0	
2	1000	0	
3	1000	0	
4	1000	0	
5	1000	0	
6	1000	0	
7	1000	0	
8	1000	0	
9	1000	0	
10	1000	0	
11	1000		
12	0		no reactions
13	0		
14	0		
15	0		
16	0		
17	0		
18	0		
19	0		
20	0		
21	0		
22	0		
23	0		
24	0		
25	0		

available levels (mm)	log heights
1000	3.0
794	2.9
631	2.8
501	2.7
398	2.6
316	2.5
251	2.4
200	2.3
158	2.2
126	2.1
100	2.0
79	1.9
63	1.8
50	1.7
40	1.6
32	1.5
25	1.4
20	1.3
16	1.2
13	1.1

1 = positive (fire)
0 = negative (no-fire)

50% height	standard deviation
>1000 mm	— log units

NOS IMPACT TEST

sample name: TNT contaminated concrete
sample ID: 200µg/cm²
sample prep: residue
requester: Anne Caris, 2150K
operator: P. Thomas/T. Woodland

date: 6/8/99
temperature: 19 °C
relative humidity: 48 %
surface: bare tools

	height (mm)	result	comments
pre-shots -->	251	0	no reaction
	501	0	no reaction
	794	0	no reaction
	1000	0	no reaction

NOS Impact tester
with type 12 tools,
5 kg drop weight,
building 888, room 105

shot #	height (mm)	result	comments
1	1000	0	
2	1000	0	
3	1000	0	
4	1000	0	
5	1000	0	
6	1000	0	
7	1000	0	
8	1000	0	
9	1000	0	
10	1000	0	
11	1000		
12	0		no reactions
13	0		
14	0		
15	0		
16	0		
17	0		
18	0		
19	0		
20	0		
21	0		
22	0		
23	0		
24	0		
25	0		

available levels (mm)	log heights
1000	3.0
794	2.9
631	2.8
501	2.7
398	2.6
316	2.5
251	2.4
200	2.3
158	2.2
126	2.1
100	2.0
79	1.9
63	1.8
50	1.7
40	1.6
32	1.5
25	1.4
20	1.3
16	1.2
13	1.1

1 = positive (fire)
0 = negative (no-fire)

50% height	standard deviation
>1000 mm	— log units

NOS IMPACT TEST

sample name: TNT contaminated steel
sample ID: 200µg/cm²
sample prep: residue
requester: Anne Caris, 2150K
operator: P. Thomas/T. Woodland

date: 6/8/99
temperature: 19 °C
relative humidity: 48 %
surface: bare tools

	height (mm)	result	comments
pre-shots -->	1000	0	no reaction

NOS Impact tester
with type 12 tools,
5 kg drop weight,
building 888, room 105

shot #	height (mm)	result	comments
1	1000	0	
2	1000	0	
3	1000	0	
4	1000	0	
5	1000	0	
6	1000	0	
7	1000	0	
8	1000	0	
9	1000	0	
10	1000	0	
11	1000		
12	0		no reactions
13	0		
14	0		
15	0		
16	0		
17	0		
18	0		
19	0		
20	0		
21	0		
22	0		
23	0		
24	0		
25	0		

available levels (mm)	log heights
1000	3.0
794	2.9
631	2.8
501	2.7
398	2.6
316	2.5
251	2.4
200	2.3
158	2.2
126	2.1
100	2.0
79	1.9
63	1.8
50	1.7
40	1.6
32	1.5
25	1.4
20	1.3
16	1.2
13	1.1

1 = positive (fire)
0 = negative (no-fire)

50% height	standard deviation
>1000 mm	-- log units

NOS IMPACT TEST

sample name: AP contaminated wood
sample ID: 500 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: P. Thomas/T. Woodland

date: 7/22/99
temperature: 20 °C
relative humidity: 50 %
surface: bare tools

	height (mm)	result	comments
pre-shots -->	1000	0	no reaction

NOS Impact tester
with type 12 tools,
5 kg drop weight,
35 mg per drop,
building 888, room 105

shot #	height (mm)	result	comments	available levels (mm)	log heights
1	1000	0		1000	3.0
2	1000	0		794	2.9
3	1000	0		631	2.8
4	1000	0		501	2.7
5	1000	0		398	2.6
6	1000	0		316	2.5
7	1000	0		251	2.4
8	1000	0		200	2.3
9	1000	0		158	2.2
10	1000	0		126	2.1
11	1000			100	2.0
12	0		no reactions	79	1.9
13	0			63	1.8
14	0			50	1.7
15	0			40	1.6
16	0			32	1.5
17	0			25	1.4
18	0			20	1.3
19	0			16	1.2
20	0			13	1.1
21	0				
22	0				
23	0				
24	0				
25	0				

1 = positive (fire)
0 = negative (no-fire)

50% height	standard deviation
>1000 mm	— log units

NOS IMPACT TEST

sample name: AP contaminated concrete
sample ID: 500 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: P. Thomas/T. Woodland

date: 7/22/99
temperature: 20 °C
relative humidity: 50 %
surface: bare tools

	height (mm)	result	comments
pre-shots -->	1000	0	no reaction

NOS Impact tester
with type 12 tools,
5 kg drop weight,
35 mg per drop,
building 888, room 105

shot #	height (mm)	result	comments
1	1000	0	
2	1000	0	
3	1000	0	
4	1000	0	
5	1000	0	
6	1000	0	
7	1000	0	
8	1000	0	
9	1000	0	
10	1000	0	
11	1000		
12	0		no reactions
13	0		
14	0		
15	0		
16	0		
17	0		
18	0		
19	0		
20	0		
21	0		
22	0		
23	0		
24	0		
25	0		

available levels (mm)	log heights
1000	3.0
794	2.9
631	2.8
501	2.7
398	2.6
316	2.5
251	2.4
200	2.3
158	2.2
126	2.1
100	2.0
79	1.9
63	1.8
50	1.7
40	1.6
32	1.5
25	1.4
20	1.3
16	1.2
13	1.1

1 = positive (fire)
0 = negative (no-fire)

50% height	standard deviation
>1000 mm	-- log units

NOS IMPACT TEST

sample name: AP contaminated steel
sample ID: 500 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: P. Thomas/T. Woodland

date: 7/22/99
temperature: 20 ℃
relative humidity: 50 %
surface: bare tools

	height (mm)	result	comments
pre-shots -->	1000	0	no reaction

NOS Impact tester
with type 12 tools,
5 kg drop weight,
35 mg per drop,
building 888, room 105

shot #	height (mm)	result	comments
1	1000	0	
2	1000	0	
3	1000	0	
4	1000	0	
5	1000	0	
6	1000	0	
7	1000	0	
8	1000	0	
9	1000	0	
10	1000	0	
11	1000		
12	0		no reactions
13	0		
14	0		
15	0		
16	0		
17	0		
18	0		
19	0		
20	0		
21	0		
22	0		
23	0		
24	0		
25	0		

available levels (mm)	log heights
1000	3.0
794	2.9
631	2.8
501	2.7
398	2.6
316	2.5
251	2.4
200	2.3
158	2.2
126	2.1
100	2.0
79	1.9
63	1.8
50	1.7
40	1.6
32	1.5
25	1.4
20	1.3
16	1.2
13	1.1

1 = positive (fire)
0 = negative (no-fire)

50% height	standard deviation
>1000 mm	-- log units

NOS IMPACT TEST

sample name: RDX contaminated wood
sample ID: 500 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: P. Thomas/T. Woodland

date: 7/22/99
temperature: 20 ℃
relative humidity: 50 %
surface: bare tools

	height (mm)	result	comments
pre-shots -->	1000	0	no reaction

NOS Impact tester
with type 12 tools,
5 kg drop weight,
35 mg per drop,
building 888, room 105

shot #	height (mm)	result	comments
1	1000	0	
2	1000	0	
3	1000	0	
4	1000	0	
5	1000	0	
6	1000	0	
7	1000	0	
8	1000	0	
9	1000	0	
10	1000	0	
11	1000		
12	0		no reactions
13	0		
14	0		
15	0		
16	0		
17	0		
18	0		
19	0		
20	0		
21	0		
22	0		
23	0		
24	0		
25	0		

available levels (mm)	log heights
1000	3.0
794	2.9
631	2.8
501	2.7
398	2.6
316	2.5
251	2.4
200	2.3
158	2.2
126	2.1
100	2.0
79	1.9
63	1.8
50	1.7
40	1.6
32	1.5
25	1.4
20	1.3
16	1.2
13	1.1

1 = positive (fire)
0 = negative (no-fire)

50% height	standard deviation
>1000 mm	-- log units

NOS IMPACT TEST

sample name: RDX contaminated concrete
sample ID: 500 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: P. Thomas/T. Woodland

date: 7/22/99
temperature: 20 ℃
relative humidity: 50 %
surface: bare tools

	height (mm)	result	comments
pre-shots -->	1000	0	no reaction

NOS Impact tester
with type 12 tools,
5 kg drop weight,
35 mg per drop,
building 888, room 105

shot #	height (mm)	result	comments
1	1000	0	
2	1000	0	
3	1000	0	
4	1000	0	
5	1000	0	
6	1000	0	
7	1000	0	
8	1000	0	
9	1000	0	
10	1000	0	
11	1000		
12	0		no reactions
13	0		
14	0		
15	0		
16	0		
17	0		
18	0		
19	0		
20	0		
21	0		
22	0		
23	0		
24	0		
25	0		

available levels (mm)	log heights
1000	3.0
794	2.9
631	2.8
501	2.7
398	2.6
316	2.5
251	2.4
200	2.3
158	2.2
126	2.1
100	2.0
79	1.9
63	1.8
50	1.7
40	1.6
32	1.5
25	1.4
20	1.3
16	1.2
13	1.1

1 = positive (fire)
0 = negative (no-fire)

50% height	standard deviation
>1000 mm	-- log units

NOS IMPACT TEST

sample name: RDX contaminated steel
sample ID: 500 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: P. Thomas/T. Woodland

date: 7/22/99
temperature: 20 ℃
relative humidity: 50 %
surface: bare tools

	height (mm)	result	comments
pre-shots -->	1000	0	no reaction

NOS Impact tester
with type 12 tools,
5 kg drop weight,
35 mg per drop,
building 888, room 105

shot #	height (mm)	result	comments
1	1000	0	
2	1000	0	
3	1000	0	
4	1000	0	
5	1000	0	
6	1000	0	
7	1000	0	
8	1000	0	
9	1000	0	
10	1000	0	
11	1000		
12	0		no reactions
13	0		
14	0		
15	0		
16	0		
17	0		
18	0		
19	0		
20	0		
21	0		
22	0		
23	0		
24	0		
25	0		

available levels (mm)	log heights
1000	3.0
794	2.9
631	2.8
501	2.7
398	2.6
316	2.5
251	2.4
200	2.3
158	2.2
126	2.1
100	2.0
79	1.9
63	1.8
50	1.7
40	1.6
32	1.5
25	1.4
20	1.3
16	1.2
13	1.1

1 = positive (fire)
0 = negative (no-fire)

50% height	standard deviation
>1000 mm	— log units

NOS IMPACT TEST

sample name: TNT contaminated wood
sample ID: 500 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: P. Thomas/T. Woodland

date: 7/22/99
temperature: 20 ℃
relative humidity: 50 %
surface: bare tools

	height (mm)	result	comments
pre-shots -->	1000	0	no reaction

NOS Impact tester
with type 12 tools,
5 kg drop weight,
35 mg per drop,
building 888, room 105

shot #	height (mm)	result	comments
1	1000	0	
2	1000	0	
3	1000	0	
4	1000	0	
5	1000	0	
6	1000	0	
7	1000	0	
8	1000	0	
9	1000	0	
10	1000	0	
11	1000		
12	0		no reactions
13	0		
14	0		
15	0		
16	0		
17	0		
18	0		
19	0		
20	0		
21	0		
22	0		
23	0		
24	0		
25	0		

available levels (mm)	log heights
1000	3.0
794	2.9
631	2.8
501	2.7
398	2.6
316	2.5
251	2.4
200	2.3
158	2.2
126	2.1
100	2.0
79	1.9
63	1.8
50	1.7
40	1.6
32	1.5
25	1.4
20	1.3
16	1.2
13	1.1

1 = positive (fire)
0 = negative (no-fire)

50% height	standard deviation
>1000 mm	— log units

NOS IMPACT TEST

sample name: TNT contaminated concrete
sample ID: 500 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: P. Thomas/T. Woodland

date: 7/22/99
temperature: 20 ℃
relative humidity: 50 %
surface: bare tools

	height (mm)	result	comments
pre-shots -->	1000	0	no reaction

NOS Impact tester
with type 12 tools,
5 kg drop weight,
35 mg per drop,
building 888, room 105

shot #	height (mm)	result	comments
1	1000	0	
2	1000	0	
3	1000	0	
4	1000	0	
5	1000	0	
6	1000	0	
7	1000	0	
8	1000	0	
9	1000	0	
10	1000	0	
11	1000		
12	0		no reactions
13	0		
14	0		
15	0		
16	0		
17	0		
18	0		
19	0		
20	0		
21	0		
22	0		
23	0		
24	0		
25	0		

available levels (mm)	log heights
1000	3.0
794	2.9
631	2.8
501	2.7
398	2.6
316	2.5
251	2.4
200	2.3
158	2.2
126	2.1
100	2.0
79	1.9
63	1.8
50	1.7
40	1.6
32	1.5
25	1.4
20	1.3
16	1.2
13	1.1

1 = positive (fire)
0 = negative (no-fire)

50% height	standard deviation
>1000 mm	-- log units

NOS IMPACT TEST

sample name: TNT contaminated steel
sample ID: 500 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: P. Thomas/T. Woodland

date: 7/22/99
temperature: 20 °C
relative humidity: 50 %
surface: bare tools

	height (mm)	result	comments
pre-shots -->	1000	0	no reaction

NOS Impact tester
with type 12 tools,
5 kg drop weight,
35 mg per drop,
building 888, room 105

shot #	height (mm)	result	comments
1	1000	0	
2	1000	0	
3	1000	0	
4	1000	0	
5	1000	0	
6	1000	0	
7	1000	0	
8	1000	0	
9	1000	0	
10	1000	0	
11	1000		
12	0		no reactions
13	0		
14	0		
15	0		
16	0		
17	0		
18	0		
19	0		
20	0		
21	0		
22	0		
23	0		
24	0		
25	0		

available levels (mm)	log heights
1000	3.0
794	2.9
631	2.8
501	2.7
398	2.6
316	2.5
251	2.4
200	2.3
158	2.2
126	2.1
100	2.0
79	1.9
63	1.8
50	1.7
40	1.6
32	1.5
25	1.4
20	1.3
16	1.2
13	1.1

1 = positive (fire)
0 = negative (no-fire)

50% height	standard deviation
>1000 mm	— log units

Appendix C

ABL FRICTION TEST RESULTS FOR CONTAMINATED WOOD PLATES

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ABL FRICTION TEST

sample name: AP contaminated wood
sample ID: 200 µg/cm²
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Chesley/T. Tolson

date: 6/8/99
temperature: 26 °C
relative humidity: 42 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980																					
750																					
560																					
420																					
315																					
235																					
180	0	0	0	0	0	0	0	0	0	0	0	0	0	0							no reactions
135	0																				no reaction
100	0																				no reaction
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: -- psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and wood anvil, in building 888 room 104

ABL FRICTION TEST

sample name: RDX contaminated wood
sample ID: 200µg / cm 2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Chesley/T. Tolson

date: 6/9/99
temperature: 26 °C
relative humidity: 41 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980																					
750																					
560																					
420																					
315																					
235																					
180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					no reactions
135																					
100																					
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: -- psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and wood anvil, in building 888 room 104

ABL FRICTION TEST

sample name: TNT contaminated wood
sample ID: 200µg/cm²
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Chesley/T. Tolson

date: 6/9/99
temperature: 26 °C
relative humidity: 42 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980																					
750																					
560																					
420																					
315																					
235																					
180	0	0	0																		no reactions
135																					
100	0	0	0	0	0	0	0	0	0	0	0	0	0								no reactions
75																					
55																					
40	0																				no reaction
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: -- psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and wood anvil, in building 888 room 104

ABL FRICTION TEST

sample name: AP contaminated wood
sample ID: 500 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson

date: 7/28/99
temperature: 26 ℃
relative humidity: 42 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980																					
750																					
560																					
420																					
315																					
235	0																				
180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						no reactions
135																					
100																					
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: **0** psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvils, in building 888 room 104

ABL FRICTION TEST

sample name: RDX contaminated wood
sample ID: 500 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson

date: 7/28/99
temperature: 26 ℃
relative humidity: 42 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980																					
750																					
560																					
420																					
315																					
235																					
180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					no reactions
135																					
100																					
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: **0** psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvils, in building 888 room 104

ABL FRICTION TEST

sample name: TNT contaminated wood
sample ID: 500 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson

date: 7/28/99
temperature: 26 ℃
relative humidity: 42 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980																					
750																					
560																					
420																					
315																					
235																					
180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					no reactions
135																					
100																					
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: **0** psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvils, in building 888 room 104

Appendix D

ABL FRICTION TEST RESULTS FOR AP-CONTAMINATED CONCRETE AND METAL PLATES

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ABL FRICTION TEST

sample name: AP contaminated concrete
sample ID: 200µg/cm²
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Chesley/T. Tolson

date: 6/8/99
temperature: 27 °C
relative humidity: 42 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980																					
750	0	0																			no reactions
560																					
420																					
315																					
235																					
180																					
135																					
100	0	0	0	0	0																no reactions
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: - - psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and concrete anvil, in building 888 room 104

ABL FRICTION TEST

sample name: AP contaminated steel
sample ID: 200 µg/cm²
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Chesley/T. Tolson

date: 6/8/99
temperature: 26 °C
relative humidity: 42 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980	0	0	0	0	0	0	0	0	0	0	0	0									no reactions
750																					
560																					
420																					
315																					
235																					
180																					
135																					
100																					
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: -- psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvil, in building 888 room 104

ABL FRICTION TEST

sample name: AP contaminated concrete
sample ID: 500 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson

date: 7/29/99
temperature: 26 °C
relative humidity: 42 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980																					
750																					
560																					
420																					
315																					
235																					
180	1																				red spark
135	0	0	0	0	1																red sparks
100	0	1																			red sparks
75	0	0	0	0	1																red sparks
55	1																				red sparks
40	0																				
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: **0** psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvils, in building 888 room 104

ABL FRICTION TEST

sample name: AP contaminated steel
sample ID: 500 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson

date: 7/28/99
temperature: 26 ℃
relative humidity: 42 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980																					
750																					
560																					
420	1																				spark
315	0	0	0	0	1																spark
235	0	0	0	0	0	0	0	1													spark
180	0	0	0	0	0	0	0	0	0	0											no reactions
135																					
100																					
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: **0** psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvils, in building 888 room 104

Appendix E

ABL FRICTION TEST RESULTS FOR RDX-CONTAMINATED CONCRETE AND METAL PLATES

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ABL FRICTION TEST

sample name: RDX contaminated concrete
sample ID: 200 µg/cm²
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Chesley/T. Tolson

date: 6/9/99
temperature: 26 ℃
relative humidity: 42 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980																					
750																					
560																					
420																					
315																					
235																					
180																					
135																					
100	0	0	0	0	0	0	0	0	0												no reactions
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: -- psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and concrete anvil, in building 888 room 104

ABL FRICTION TEST

sample name: RDX contaminated concrete
sample ID: 500 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson

date: 7/29/99
temperature: 26 ℃
relative humidity: 42 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980																					
750																					
560																					
420																					
315																					
235																					
180	1																				red sparks
135	1																				red sparks
100	1																				red sparks
75	0	0	0	0	0	1															red sparks
55	0	0	0	1																	red spark
40	1																				red spark
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: **0** psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvils, in building 888 room 104

ABL FRICTION TEST

sample name: RDX contaminated steel
sample ID: 200µg / cm 2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Chesley/T. Tolson

date: 6/8/99
temperature: 27 ℃
relative humidity: 43 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980	0	0	0	0	0	0	0	1													spark
750	0	1																			spark
560	0	0	0	0	0	0	0	0	0	0	0										no reactions
420																					
315																					
235																					
180																					
135																					
100																					
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: - - psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvil, in building 888 room 104

ABL FRICTION TEST

sample name: RDX contaminated steel
sample ID: 150 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson

date: 7/27/99
temperature: 26 ℃
relative humidity: 42 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980	0	1																			spark
750	1																				spark
560	0	0	1																		spark
420	0	0	0	0	0	0	1														spark
315	1																				spark
235	1																				spark
180	0	0	1																		spark
135	1																				spark
100	1																				spark
75	0	0	1																		spark
55	1																				spark
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: **0** psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvils, in building 888 room 104

ABL FRICTION TEST

sample name: RDX contaminated steel
sample ID: 100 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson

date: 7/27/99
temperature: 26 ℃
relative humidity: 42 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980	1																				spark
750	1																				spark
560	1																				spark
420	1																				spark
315	1																				spark
235	0	0	0	0	0	0	1														spark
180	1																				spark
135	0	0	0	0	0	0	0	0	0	0	0	0									no reactions
100																					
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: **0** psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvils, in building 888 room 104

ABL FRICTION TEST

sample name: RDX contaminated steel
sample ID: #1, 75 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Chesley

date: 9/22/99
temperature: 26 ℃
relative humidity: 40 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	no reactions
750																					
560																					
420																					
315																					
235																					
180																					
135																					
100																					
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: **>980** psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvils, in building 888 room 104

ABL FRICTION TEST

sample name: RDX contaminated steel
sample ID: #2, 50 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Chesley

date: 9/24/99
temperature: 26 ℃
relative humidity: 40 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	no reactions
750																					
560																					
420																					
315																					
235																					
180																					
135																					
100																					
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: **>980** psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvils, in building 888 room 104

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Appendix F

ABL FRICTION TEST RESULTS FOR TNT-CONTAMINATED CONCRETE AND METAL PLATES

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ABL FRICTION TEST

sample name: TNT contaminated concrete
sample ID: 200µg / cm 2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Chesley/T. Tolson

date: 6/9/99
temperature: 26 °C
relative humidity: 42 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980																					
750																					
560																					
420																					
315																					
235																					
180																					
135																					
100	0	0	0	0	0	0	0	0													no reactions
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: - - psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and concrete anvil, in building 888 room 104

ABL FRICTION TEST

sample name: TNT contaminated steel
sample ID: 200ug / cm 2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Chesley/T. Tolson

date: 6/9/99
temperature: 26 °C
relative humidity: 42 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	no reactions
750																					
560																					
420																					
315																					
235																					
180																					
135																					
100																					
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: **>980** psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvil, in building 888 room 104

ABL FRICTION TEST

sample name: TNT contaminated concrete
sample ID: 500 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson

date: 7/29/99
temperature: 26 ℃
relative humidity: 42 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980	0	0	0	0	0	0	0	0	0	0	1										spark
750	0	1																			spark
560	0	0	1																		spark
420	1																				spark
315	0	1																			spark
235	0	0	0	0																	
180	0																				
135																					
100																					
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: **0** psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvils, in building 888 room 104

ABL FRICTION TEST

sample name: TNT contaminated steel
sample ID: 500 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson

date: 7/28/99
temperature: 26 ℃
relative humidity: 42 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980	0	0	0	0	0	0	0	0	0	0	0	0	0	1							burn mark
750	0	0	0	0	0	0	0														no reactions
560																					
420	0																				
315																					
235	0																				
180	0																				
135																					
100																					
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: **0** psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvils, in building 888 room 104

Appendix G

ELECTROSTATIC DISCHARGE TEST RESULTS AT 200-µg/cm^2 CONTAMINATION LEVEL

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ABL ELECTROSTATIC DISCHARGE TEST

sample name: AP contaminated steel
sample ID: 200 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson

date: 8/12/99
temperature: 26 ℃
relative humidity: 42 %

capacitance (µ farad)	joules	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
0.5	8.33	0	0	0	0	1																spark
0.25	4.20	0	0	0	0	0	0	0	0	1												spark
0.1	1.72	0	0	0	0	0	0															
0.05	0.853																					
0.02	0.326																					
0.01	0.165																					NOTE: tested on 20 sample
0.005	0.095																					holders provided by 2150K
0.002	0.037																					
0.001	0.023																					
0.0005	0.015																					
0.0002	0.010																					
0.0001	0.0084																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL ESD: **0** joules

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL Model 150 ESD tester,
voltage = 5.785 KV DC, tested in building 888 room 104

ABL ELECTROSTATIC DISCHARGE TEST

sample name: RDX contaminated steel
sample ID: 200 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson

date: 8/13/99
temperature: 26 ℃
relative humidity: 42 %

capacitance (µ farad)	joules	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
0.5	8.33	0	0	0	0	0	1															sparks
0.25	4.20	0	0	0	1																	spark
0.1	1.72	0	0	0	0	0	0	0	0	0	0											spark
0.05	0.853																					
0.02	0.326																					
0.01	0.165																					NOTE: tested on 20 sample
0.005	0.095																					holders provided by 2150K
0.002	0.037																					
0.001	0.023																					
0.0005	0.015																					
0.0002	0.010																					
0.0001	0.0084																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL ESD: **0** joules

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL Model 150 ESD tester,
voltage = 5.785 KV DC, tested in building 888 room 104

ABL ELECTROSTATIC DISCHARGE TEST

sample name: TNT contaminated steel
sample ID: 200 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson

date: 8/13/99
temperature: 26 ℃
relative humidity: 42 %

capacitance (µ farad)	joules	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
0.5	8.33	0	1																			spark
0.25	4.20	0	0	0	1																	spark
0.1	1.72	0	0	0	0	1																spark
0.05	0.853	0	0	0	0	0	0	0	0	1												spark
0.02	0.326																					
0.01	0.165																					
0.005	0.095																					NOTE: tested on 20 sample
0.002	0.037																					holders provided by 2150K
0.001	0.023																					
0.0005	0.015																					
0.0002	0.010																					
0.0001	0.0084																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL ESD: **0** joules

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL Model 150 ESD tester,
voltage = 5.785 KV DC, tested in building 888 room 104

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Appendix H

ELECTROSTATIC DISCHARGE TEST RESULTS AT 100-µg/cm^2 CONTAMINATION LEVEL

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ABL ELECTROSTATIC DISCHARGE TEST

sample name: AP contaminated steel
sample ID: 100 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson

date: 9/27/99
temperature: 25 ℃
relative humidity: 41 %

capacitance (µ farad)	joules	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
0.5	8.33	0	0	0	0	0	0	0	0	0	0	1										white sparks
0.25	4.20																					
0.1	1.72																					
0.05	0.853																					
0.02	0.326																					
0.01	0.165																					
0.005	0.095																					
0.002	0.037																					
0.001	0.023																					
0.0005	0.015																					
0.0002	0.010																					
0.0001	0.0084																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL ESD: **0** joules

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL Model 150 ESD tester,
voltage = 5.785 KV DC, tested in building 888 room 104

ABL ELECTROSTATIC DISCHARGE TEST

sample name: RDX contaminated steel
sample ID: 100 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: P. Thomas/T. Chesley/T. Woodland

date: 9/25/99
temperature: 25 °C
relative humidity: 40 %

capacitance (µ farad)	joules	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
0.5	8.33	0	0	0	1																	yellow flash
0.25	4.20	0	0	0	0	0	0	0	1													yellow flash
0.1	1.72																					
0.05	0.853																					
0.02	0.326																					
0.01	0.165																					
0.005	0.095																					
0.002	0.037																					
0.001	0.023																					
0.0005	0.015																					
0.0002	0.010																					
0.0001	0.0084																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

20 TIL ESD: **0** joules

Tested on ABL Model 150 ESD tester,
voltage = 5.785 KV DC, tested in building 888 room 104

ABL ELECTROSTATIC DISCHARGE TEST

sample name: TNT contaminated steel
sample ID: 100µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson

date: 9/27/99
temperature: 25 ℃
relative humidity: 42 %

capacitance (µ farad)	joules	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
0.5	8.33	0	0	0	0	0	1															orange sparks
0.25	4.20																					
0.1	1.72																					
0.05	0.853																					
0.02	0.326																					
0.01	0.165																					
0.005	0.095																					
0.002	0.037																					
0.001	0.023																					
0.0005	0.015																					
0.0002	0.010																					
0.0001	0.0084																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL ESD: **0** joules

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL Model 150 ESD tester,
voltage = 5.785 KV DC, tested in building 888 room 104

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Appendix I

ELECTROSTATIC DISCHARGE TEST RESULTS AT 75-µg/cm^2 CONTAMINATION LEVEL

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ABL ELECTROSTATIC DISCHARGE TEST

sample name: AP contaminated steel
sample ID: 75 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson/T. Chesley/D. Remmers

date: 10/26/99
temperature: 29 °C
relative humidity: 38 %

capacitance (µ farad)	joules	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
0.5	8.33	1																				yellow sparks
0.25	4.20																					
0.1	1.72																					
0.05	0.853																					
0.02	0.326																					
0.01	0.165																					
0.005	0.095																					
0.002	0.037																					
0.001	0.023																					
0.0005	0.015																					
0.0002	0.010																					
0.0001	0.0084																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL ESD: **0** joules

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL Model 150 ESD tester,
voltage = 5.785 KV DC, tested in building 888 room 104

ABL ELECTROSTATIC DISCHARGE TEST

sample name: RDX contaminated steel
sample ID: 75 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson/T. Chesley/D. Remmers

date: 10/26/99
temperature: 29 °C
relative humidity: 38 %

capacitance (µ farad)	joules	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
0.5	8.33	1																				yellow/orange sparks
0.25	4.20																					
0.1	1.72																					
0.05	0.853																					
0.02	0.326																					
0.01	0.165																					
0.005	0.095																					
0.002	0.037																					
0.001	0.023																					
0.0005	0.015																					
0.0002	0.010																					
0.0001	0.0084																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL ESD: **0** joules

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL Model 150 ESD tester,
voltage = 5.785 KV DC, tested in building 888 room 104

ABL ELECTROSTATIC DISCHARGE TEST

sample name: TNT contaminated steel
sample ID: 75 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson/D. Remmers/T. Chesley

date: 10/26/99
temperature: 26 °C
relative humidity: 38 %

capacitance (µ farad)	joules	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
0.5	8.33	0	0	0	0	0	0	1														orange sparks
0.25	4.20																					
0.1	1.72																					
0.05	0.853																					
0.02	0.326																					
0.01	0.165																					
0.005	0.095																					
0.002	0.037																					
0.001	0.023																					
0.0005	0.015																					
0.0002	0.010																					
0.0001	0.0084																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL ESD: **0** joules

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL Model 150 ESD tester,
voltage = 5.785 KV DC, tested in building 888 room 104

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Appendix J

ELECTROSTATIC DISCHARGE TEST RESULTS AT 50-µg/cm^2 CONTAMINATION LEVEL

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ABL ELECTROSTATIC DISCHARGE TEST

sample name: AP contaminated steel
sample ID: 50 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson/T. Chesley/D. Remmers

date: 10/26/99
temperature: 29 °C
relative humidity: 38 %

capacitance (µ farad)	joules	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
0.5	8.33	0	0	0	1																	orange sparks
0.25	4.20																					
0.1	1.72																					
0.05	0.853																					
0.02	0.326																					
0.01	0.165																					
0.005	0.095																					
0.002	0.037																					
0.001	0.023																					
0.0005	0.015																					
0.0002	0.010																					
0.0001	0.0084																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL ESD: **0** joules

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL Model 150 ESD tester,
voltage = 5.785 KV DC, tested in building 888 room 104

ABL ELECTROSTATIC DISCHARGE TEST

sample name: RDX contaminated steel
sample ID: 50 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson/T. Chesley/D. Remmers

date: 10/26/99
temperature: 29 °C
relative humidity: 38 %

capacitance (µ farad)	joules	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
0.5	8.33	0	0	0	1																	orange sparks
0.25	4.20																					
0.1	1.72																					
0.05	0.853																					
0.02	0.326																					
0.01	0.165																					
0.005	0.095																					
0.002	0.037																					
0.001	0.023																					
0.0005	0.015																					
0.0002	0.010																					
0.0001	0.0084																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL ESD: **0** joules

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL Model 150 ESD tester,
voltage = 5.785 KV DC, tested in building 888 room 104

ABL ELECTROSTATIC DISCHARGE TEST

sample name: TNT contaminated steel
sample ID: 50 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson/D. Remmers/T. Chesley

date: 10/26/99
temperature: 26 °C
relative humidity: 38 %

capacitance (µ farad)	joules	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
0.5	8.33	1																				orange/yellow sparks
0.25	4.20																					
0.1	1.72																					
0.05	0.853																					
0.02	0.326																					
0.01	0.165																					
0.005	0.095																					
0.002	0.037																					
0.001	0.023																					
0.0005	0.015																					
0.0002	0.010																					
0.0001	0.0084																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL ESD: **0** joules

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL Model 150 ESD tester,
voltage = 5.785 KV DC, tested in building 888 room 104

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Appendix K

SCANNING ELECTRON MICROGRAPHS

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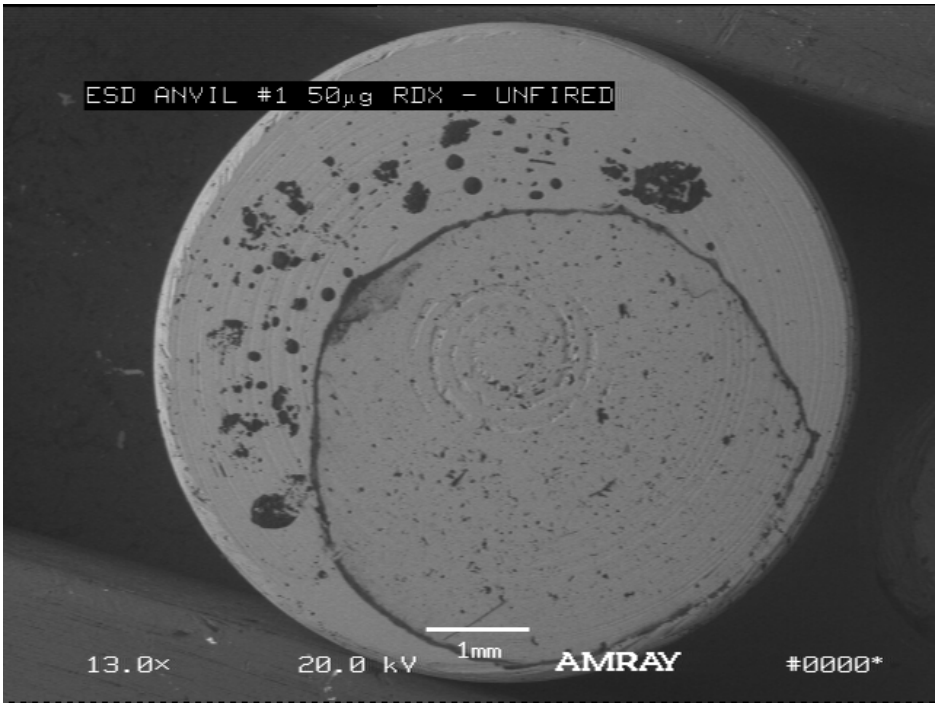
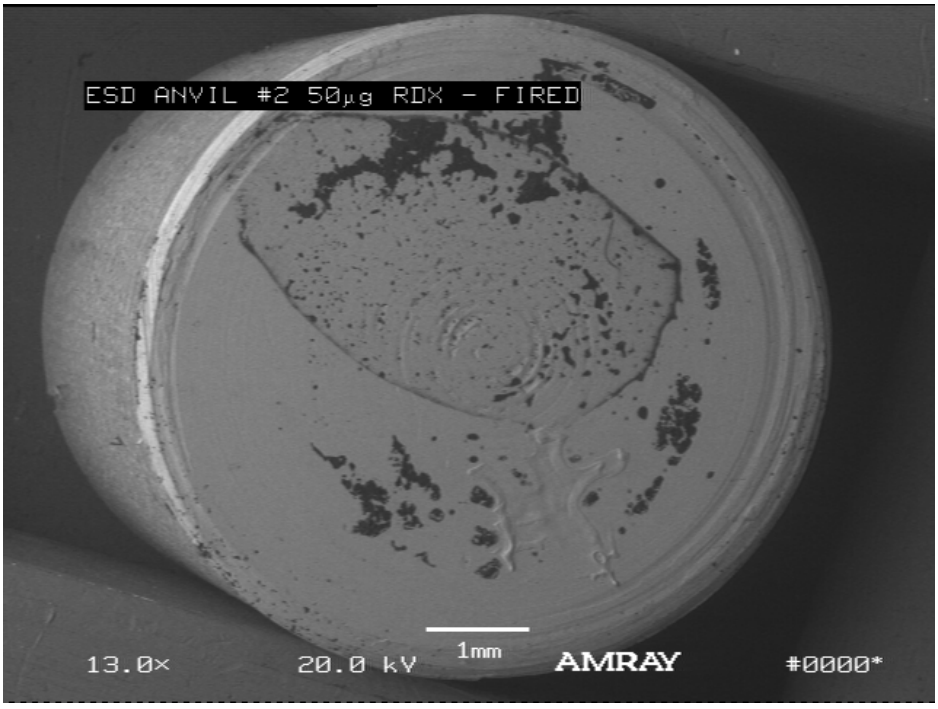
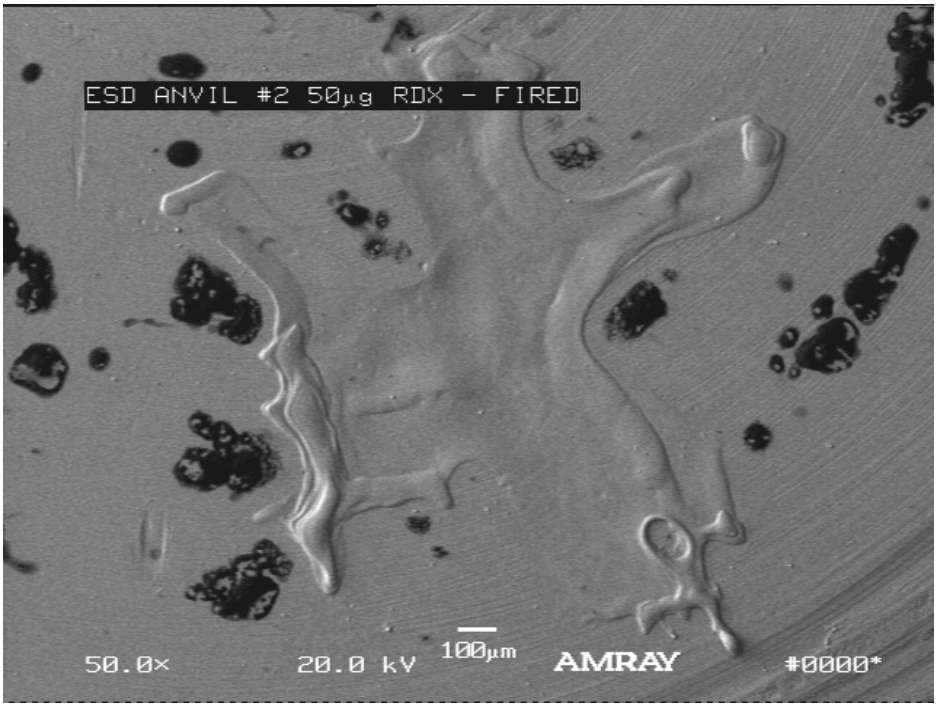
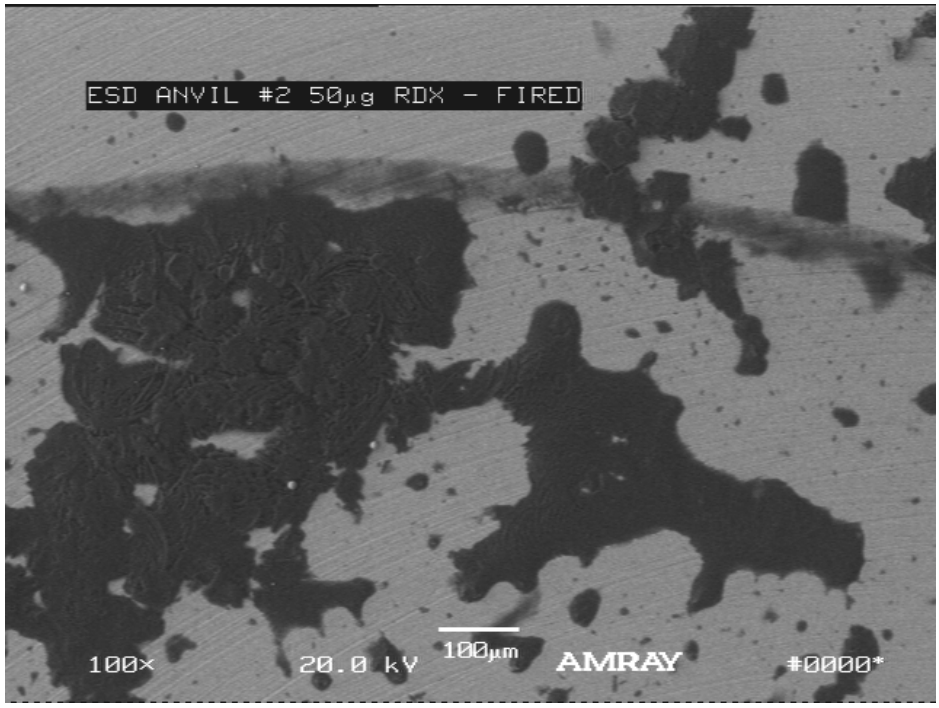
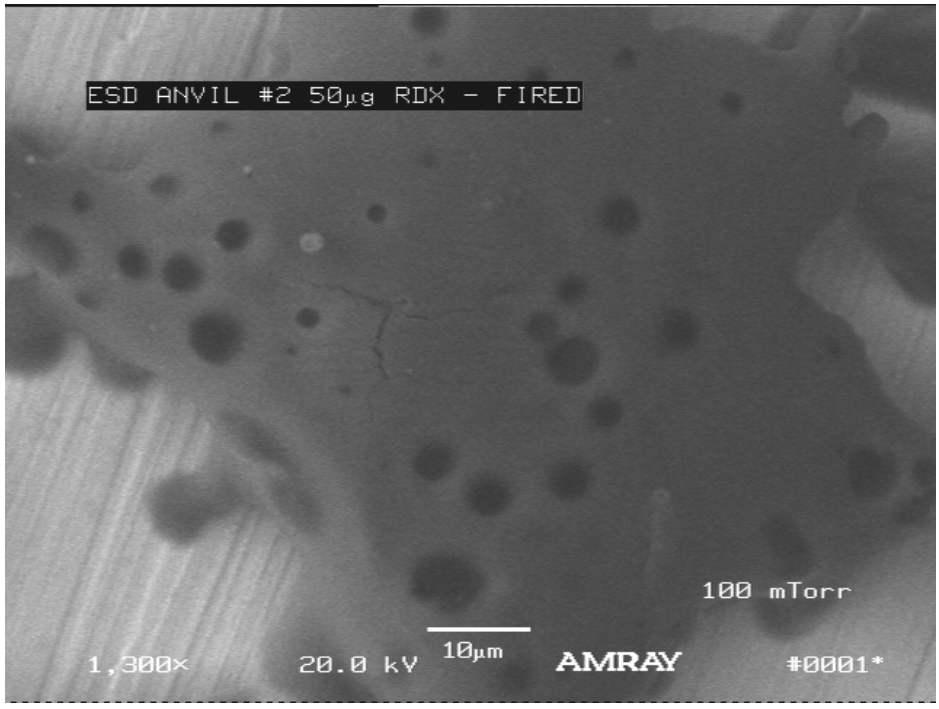

ESD ANVIL #1 50µg RDX - UNFIRED
1mm
13.0×
20.0 kV
AMRAY
#0000*

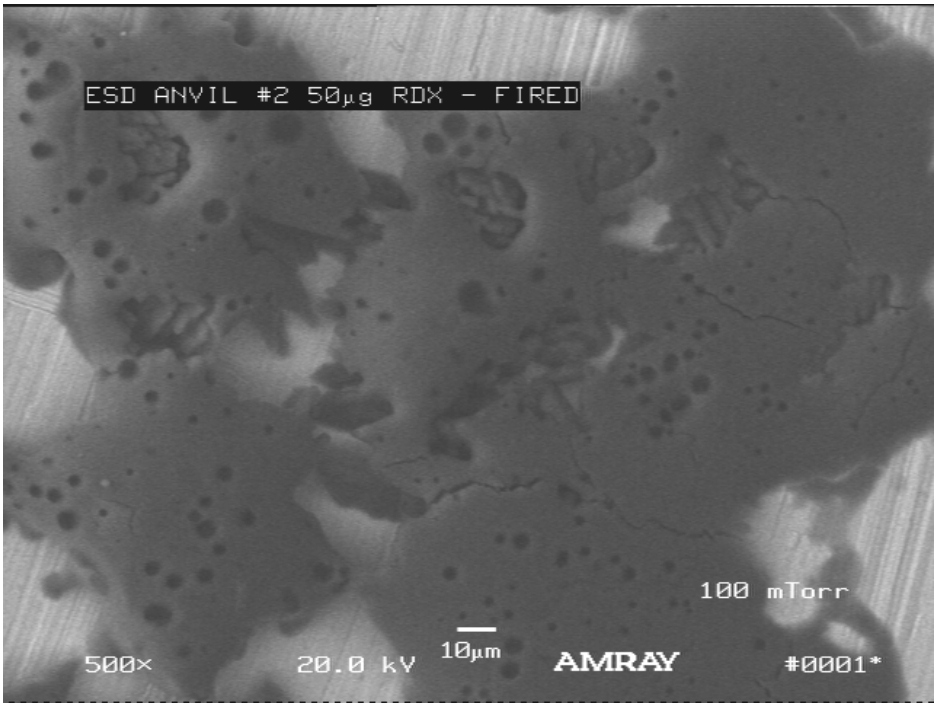

ESD ANVIL #2 50µg RDX - FIRED
1mm
13.0×
20.0 kV
AMRAY
#0000*


ESD ANVIL #2 50µg RDX - FIRED
50.0×
20.0 kV
100µm
AMRAY
#0000*

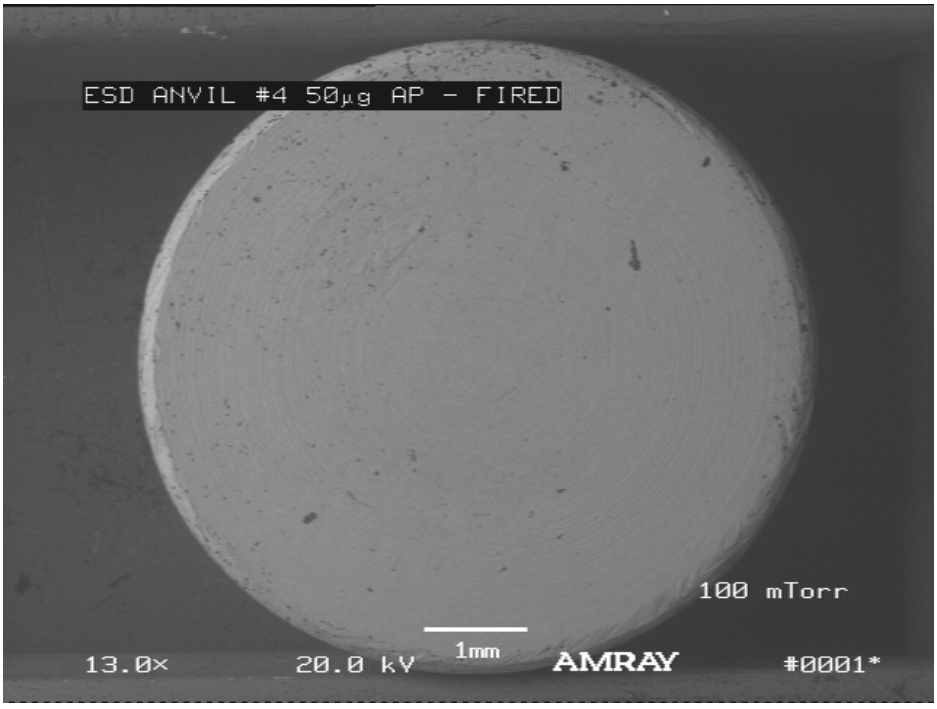

ESD ANVIL #2 50µg RDX - FIRED
1,300×
20.0 kV
10µm
AMRAY
#0000*

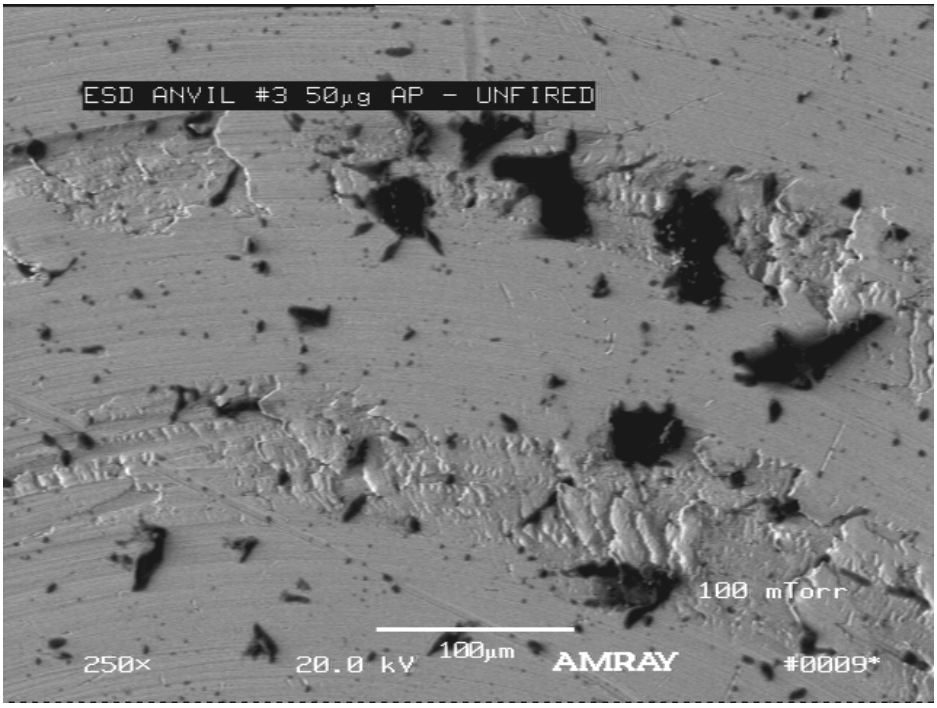

ESD ANVIL #2 50µg RDX - FIRED
100×
20.0 kV
100µm
AMRAY
#0000*

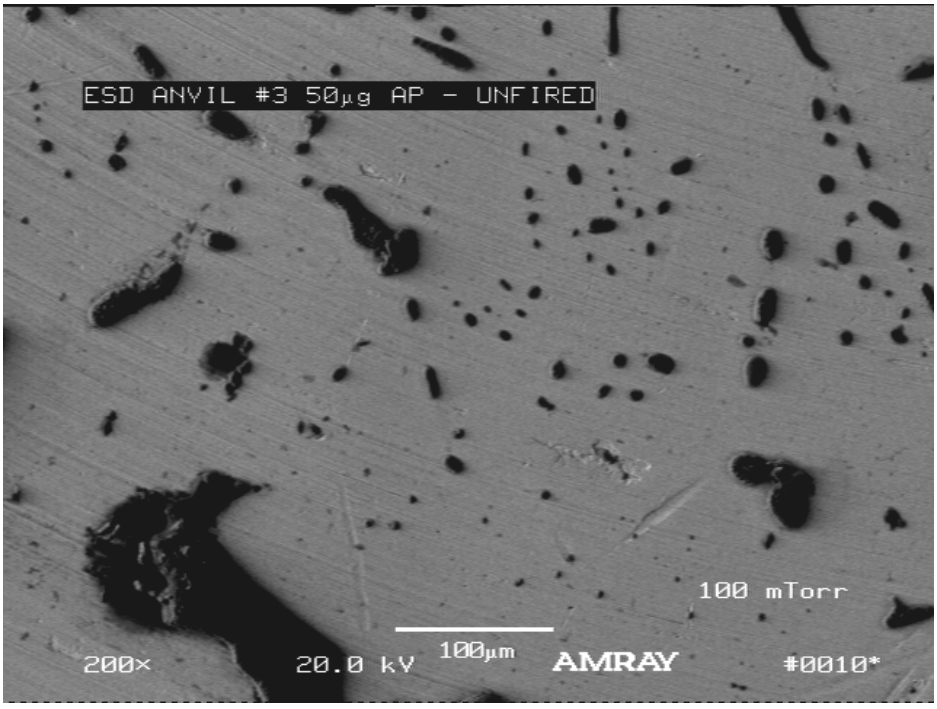

ESD ANVIL #2 50µg RDX - FIRED
100 mTorr
1,300×
20.0 kV
10µm
AMRAY
#0001*


ESD ANVIL #2 50µg RDX - FIRED
100 mTorr
500×
20.0 kV
10µm
AMRAY
#0001*

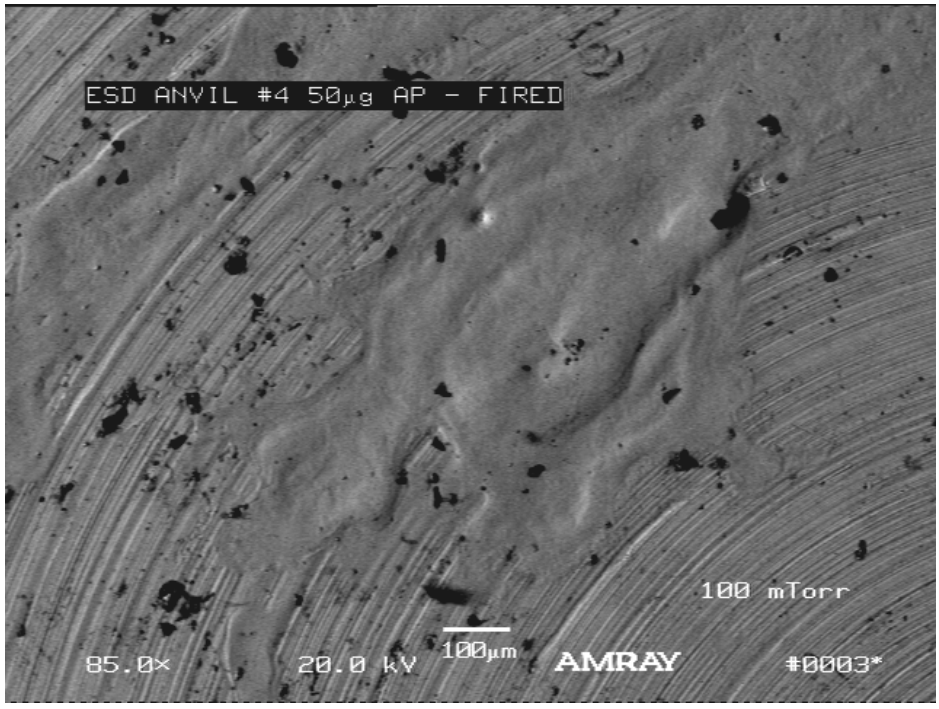

ESD ANVIL #3 50µg AP - UNFIRED
100 mTorr
1mm
13.0×
20.0 kV
AMRAY
#0007*

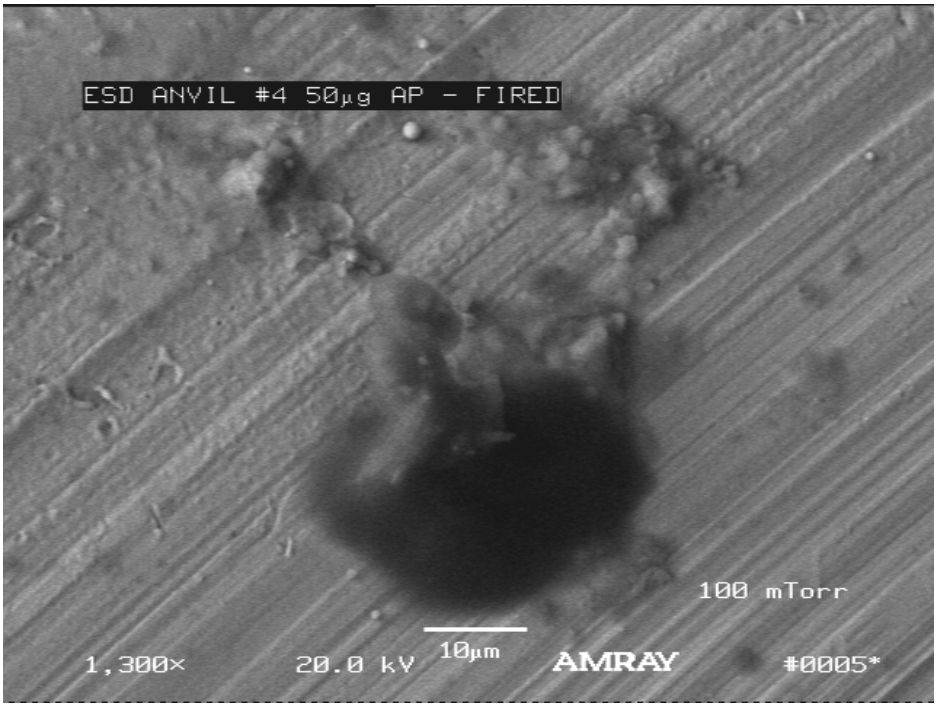

ESD ANVIL #4 50µg AP - FIRED
100 mTorr
1mm
13.0×
20.0 kV
AMRAY
#0001*

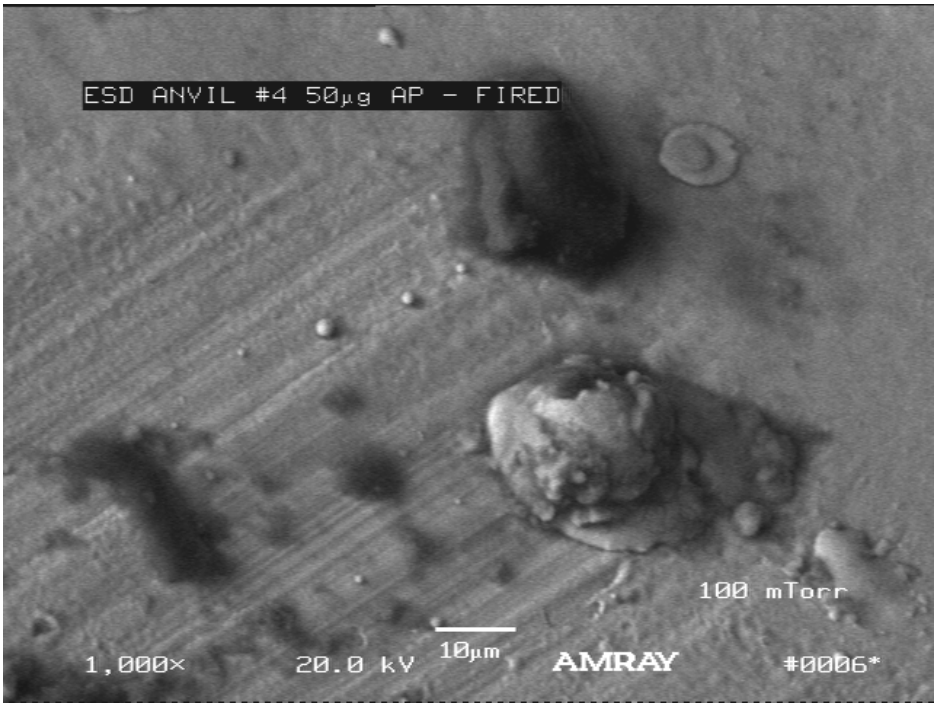

ESD ANVIL #3 50µg AP - UNFIRED
100 mTorr
250×
20.0 kV
100µm
AMRAY
#0009*

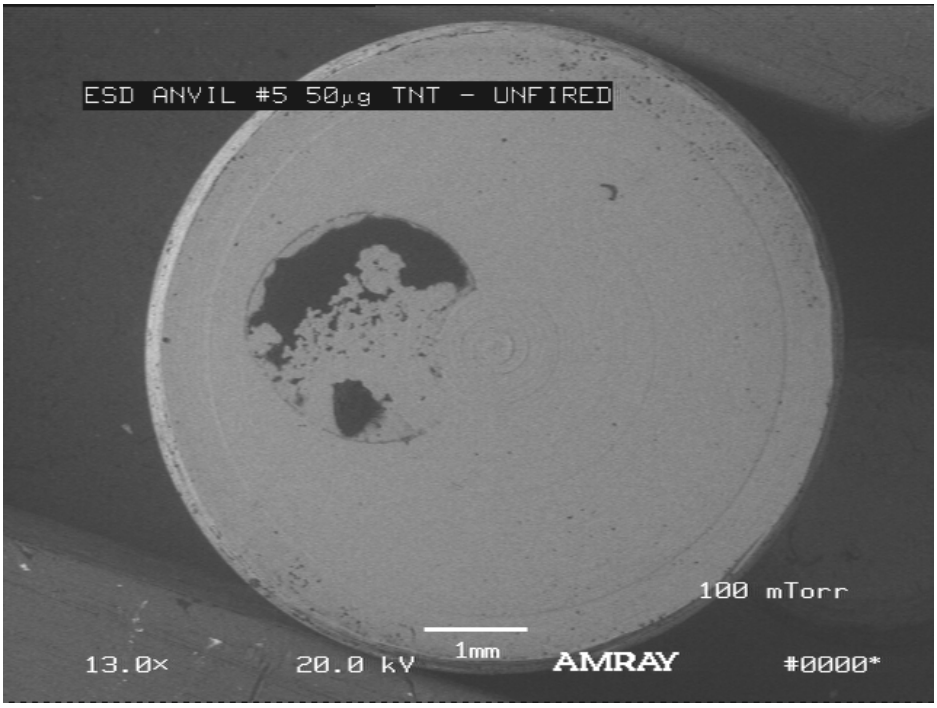

ESD ANVIL #3 50µg AP - UNFIRED
100 mTorr
200×
20.0 kV
100µm
AMRAY
#0010*

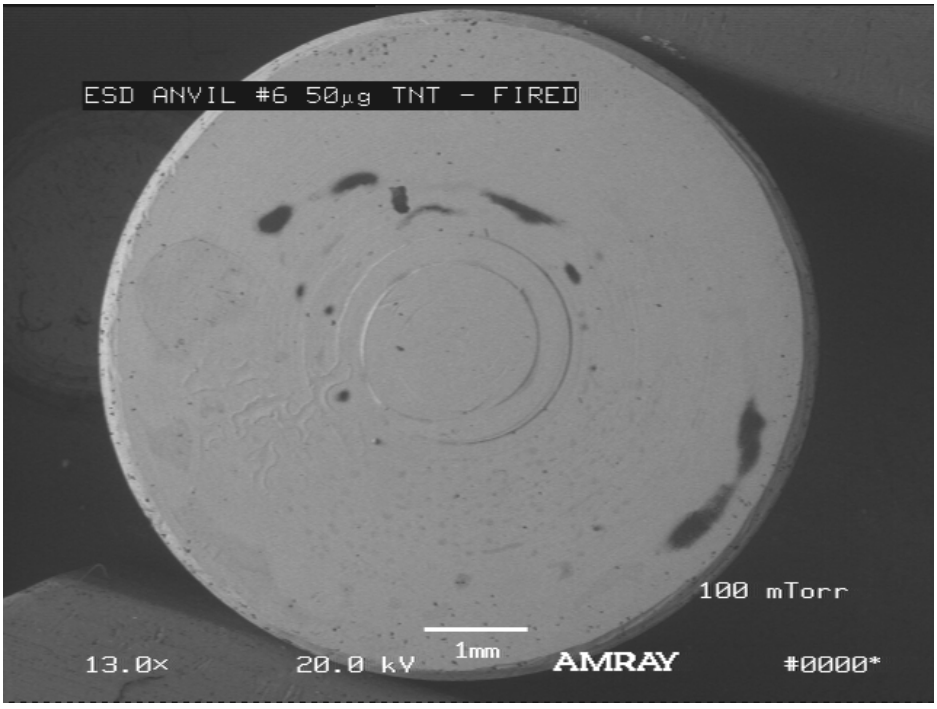

ESD ANVIL #4 50µg AP - FIRED
100 mTorr
200×
20.0 kV
100µm
AMRAY
#0002*

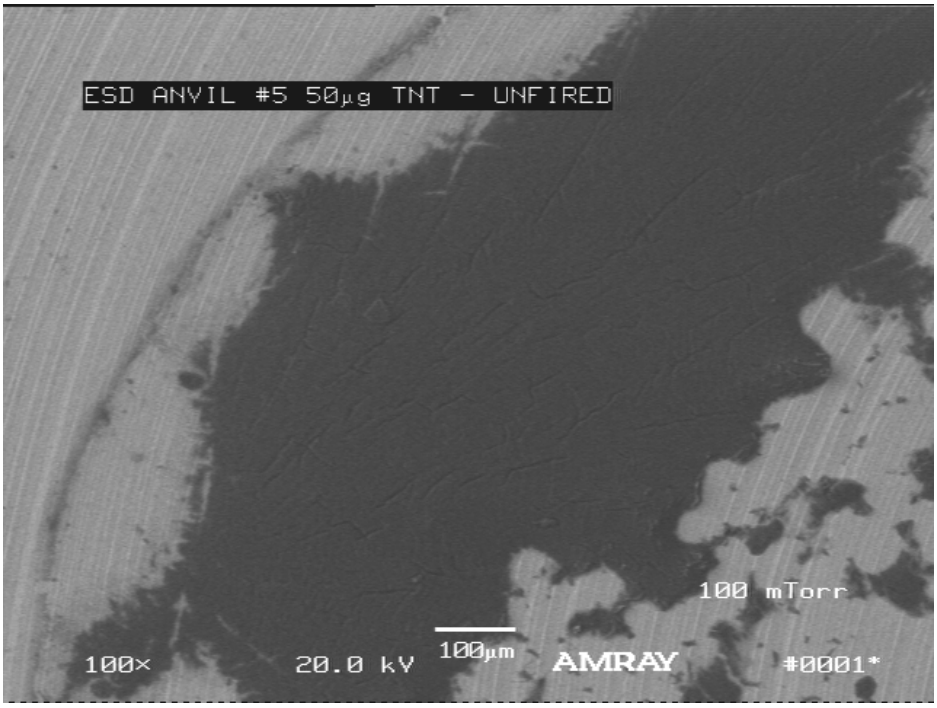

ESD ANVIL #4 50µg AP - FIRED
100 mTorr
85.0×
20.0 kV
100µm
AMRAY
#0003*

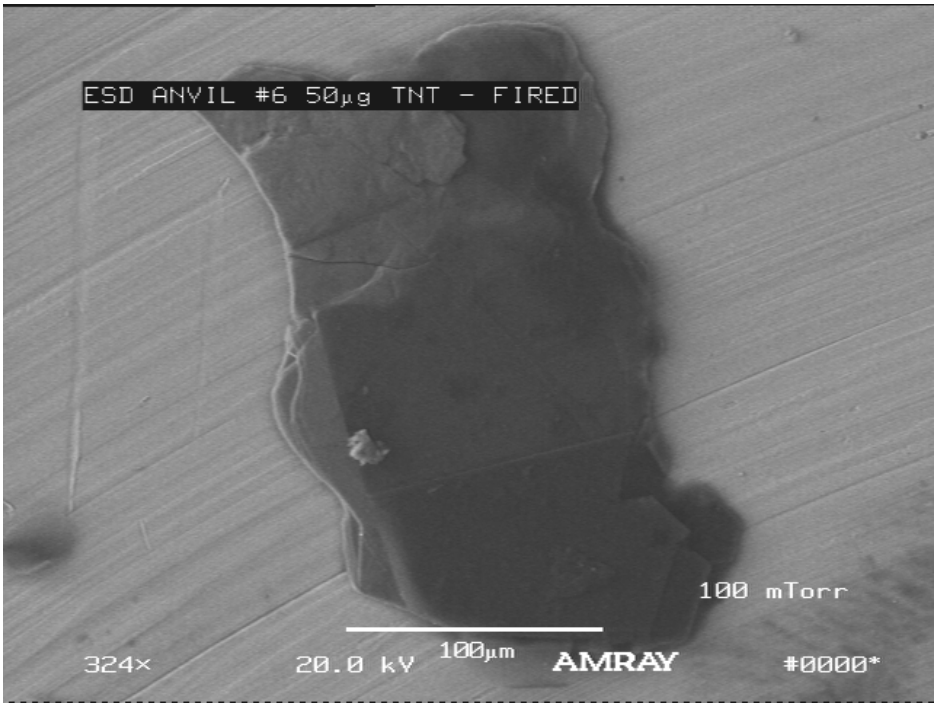

ESD ANVIL #4 50µg AP - FIRED
100 mTorr
10µm
1,300× 20.0 kV AMRAY #0005*

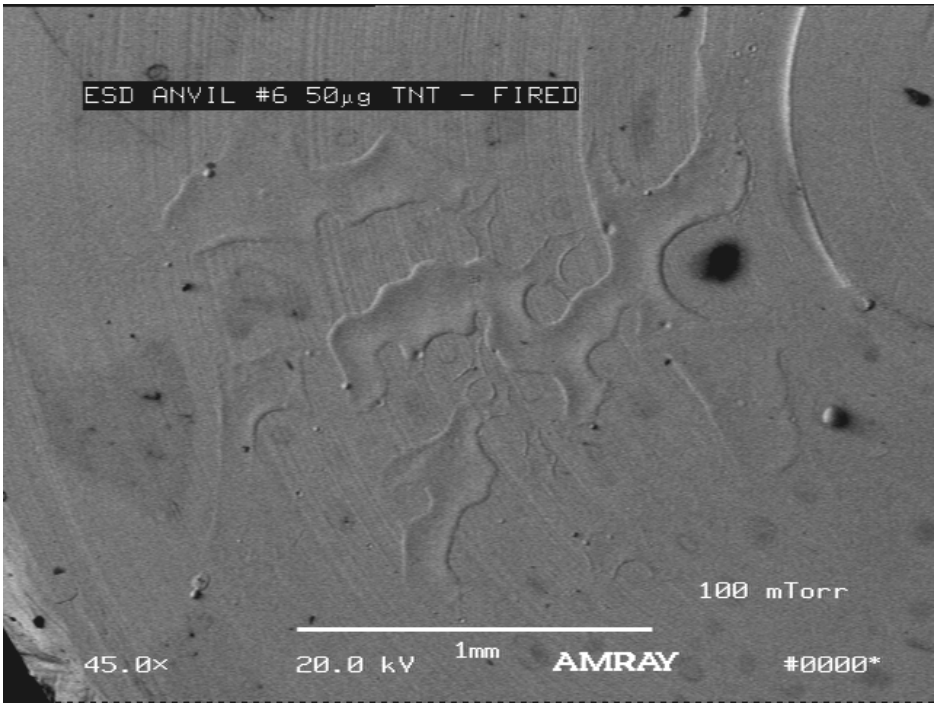

ESD ANVIL #4 50µg AP - FIRED
100 mTorr
10µm
1,000× 20.0 kV AMRAY #0006*

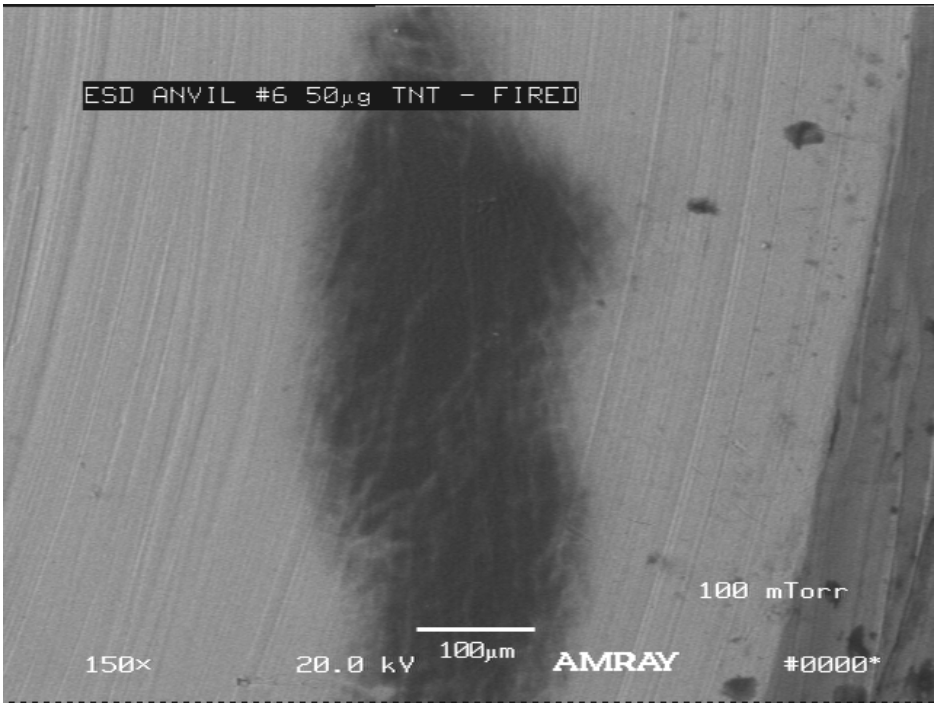

ESD ANVIL #5 50µg TNT - UNFIRED
100 mTorr
1mm
13.0×
20.0 kV
AMRAY
#0000*

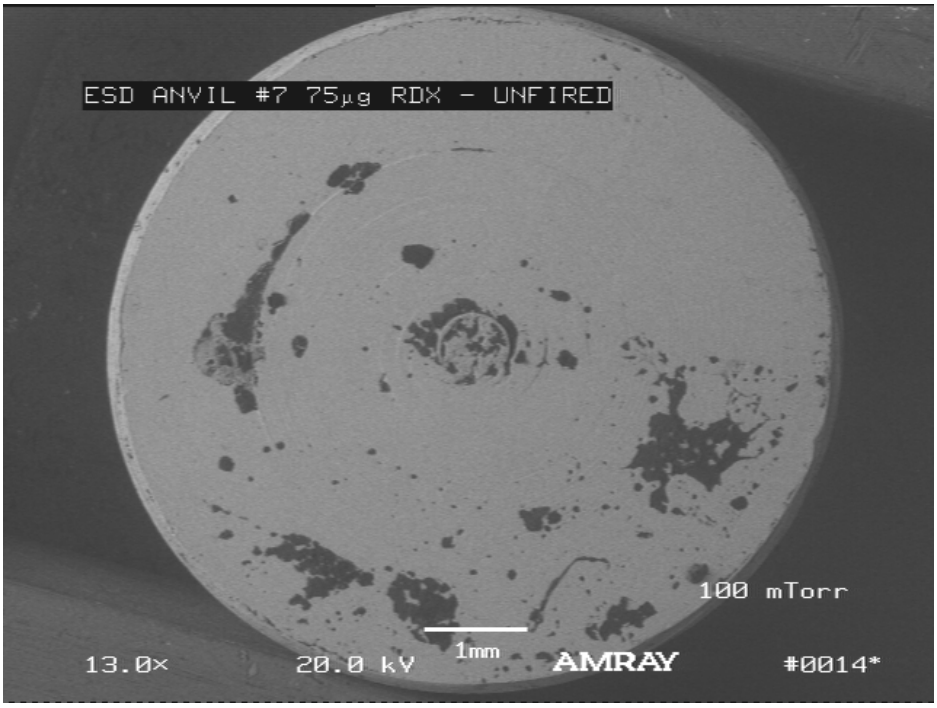

ESD ANVIL #6 50µg TNT - FIRED
100 mTorr
1mm
13.0×
20.0 kV
AMRAY
#0000*

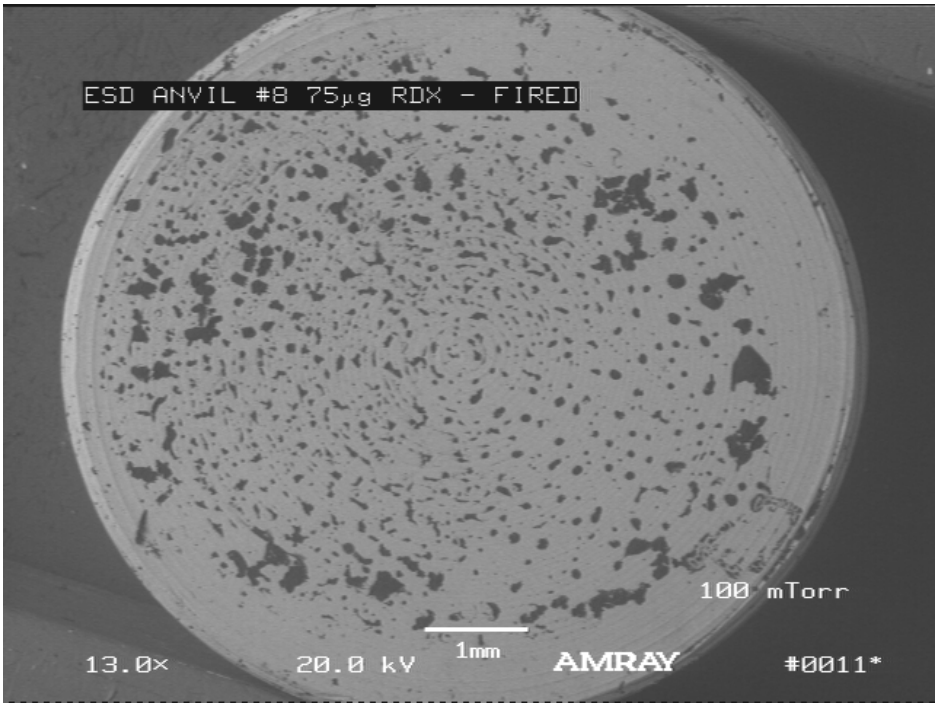

ESD ANVIL #5 50µg TNT - UNFIRED
100 mTorr
100×
20.0 kV
100µm
AMRAY
#0001*

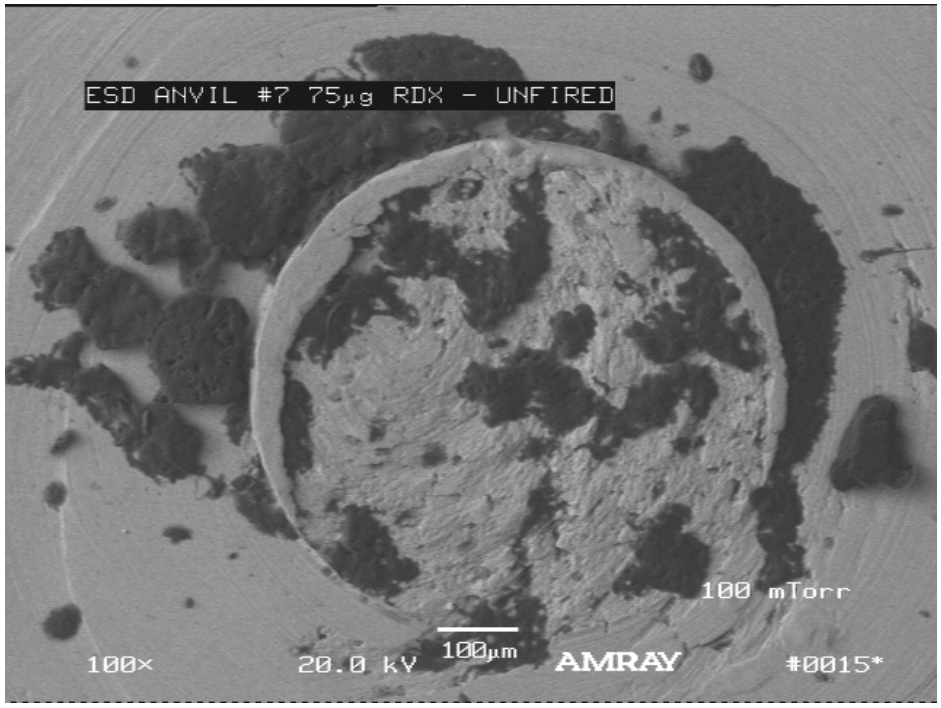

ESD ANVIL #6 50µg TNT - FIRED
100 mTorr
324×
20.0 kV
100µm
AMRAY
#0000*


ESD ANVIL #6 50µg TNT - FIRED
100 mTorr
45.0×
20.0 kV
1mm
AMRAY
#0000*

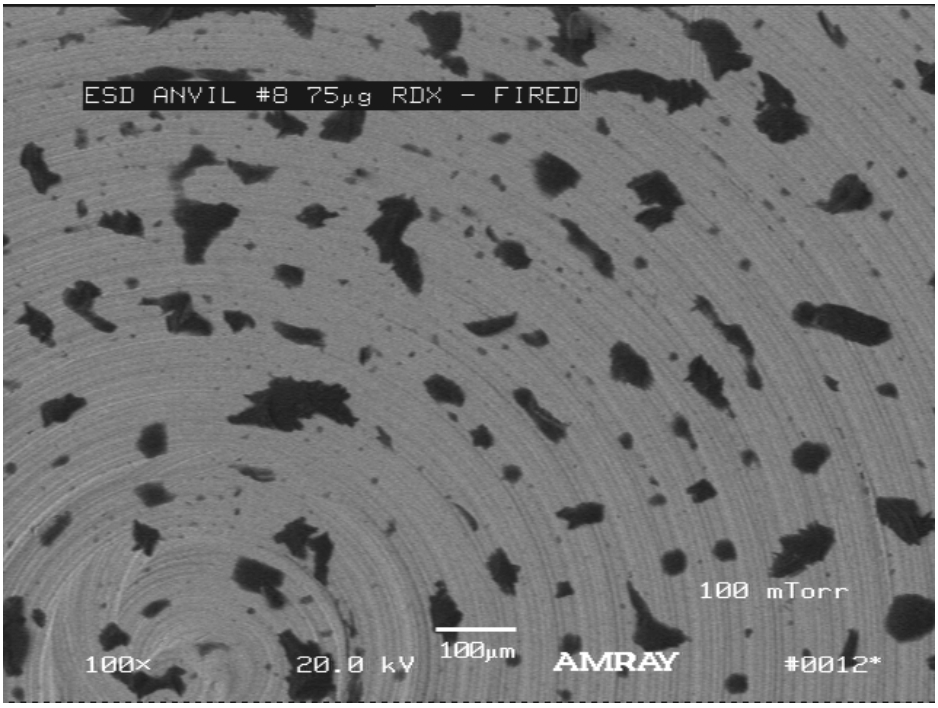

ESD ANVIL #6 50µg TNT - FIRED
100 mTorr
150×
20.0 kV
100µm
AMRAY
#0000*

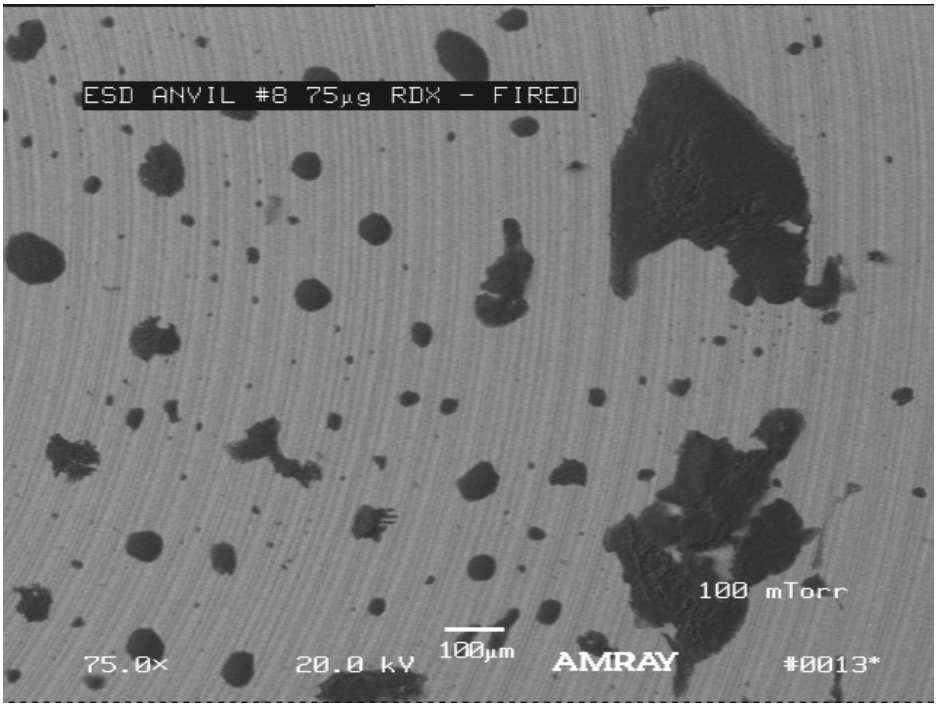

ESD ANVIL #7 75µg RDX - UNFIRED
100 mTorr
1mm
13.0×
20.0 kV
AMRAY
#0014*


ESD ANVIL #8 75µg RDX - FIRED
100 mTorr
1mm
13.0×
20.0 kV
AMRAY
#0011*


ESD ANVIL #7 75µg RDX - UNFIRED
100 mTorr
100×
20.0 kV
100µm
AMRAY
#0015*


ESD ANVIL #7 75µg RDX - UNFIRED
100 mTorr
300×
20.0 kV
100µm
AMRAY
#0016*

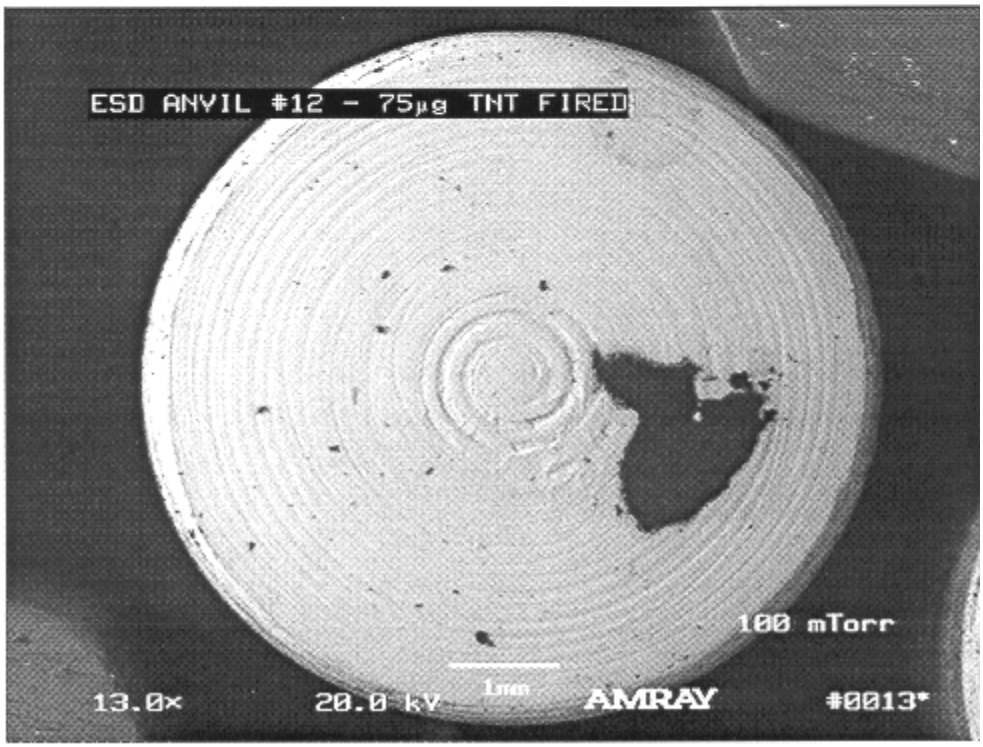

ESD ANVIL #8 75µg RDX - FIRED
100 mTorr
100×
20.0 kV
100µm
AMRAY
#0012*


ESD ANVIL #8 75µg RDX - FIRED
100 mTorr
75.0×
20.0 kV
100µm
AMRAY
#0013*


ESD ANVIL #9 - 75µg AP UNFIRED
100 mTorr
1mm
13.0× 20.0 kV AMRAY #0000*


ESD ANVIL #10 - 75µg AP FIRED
100 mTorr
1mm
13.0× 20.0 kV AMRAY #0004*


ESD ANVIL #11 - 75µg TNT UNFIRED
100 mTorr
1µm
13.0× 20.0 kV AMRAY #0012*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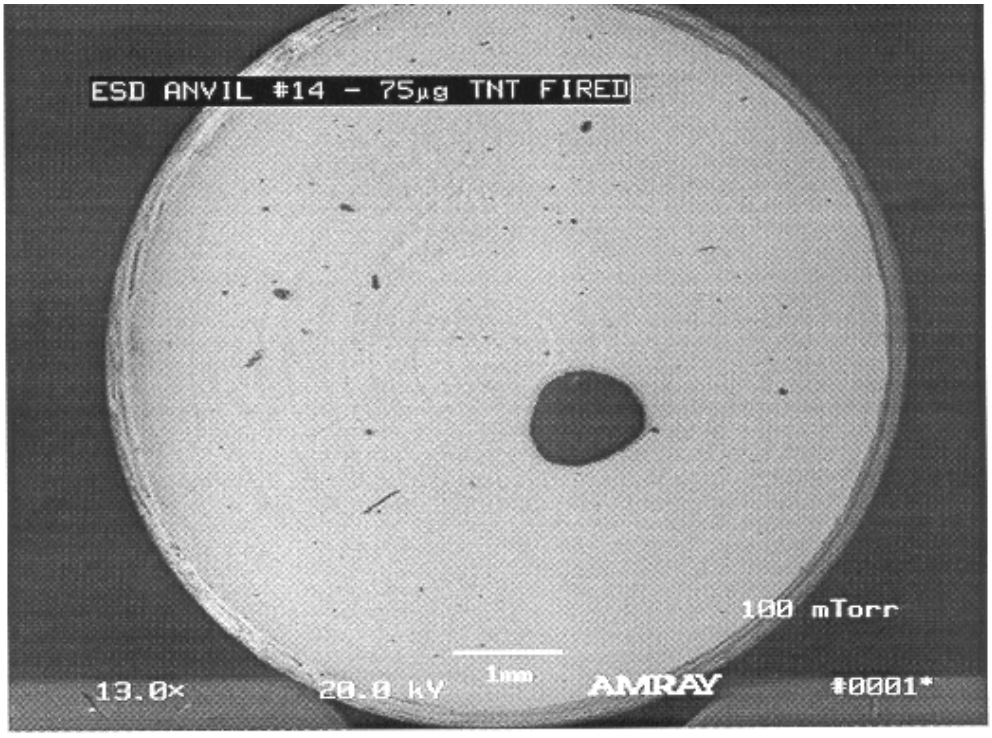
100 mTorr
1µm
13.0× 20.0 kV AMRAY #0013*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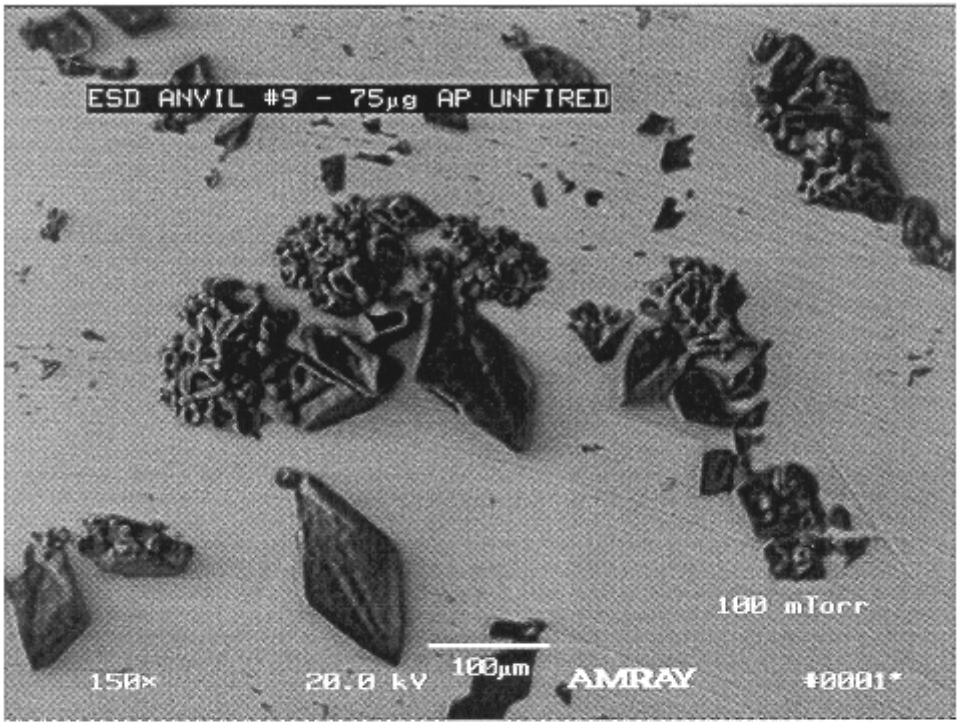
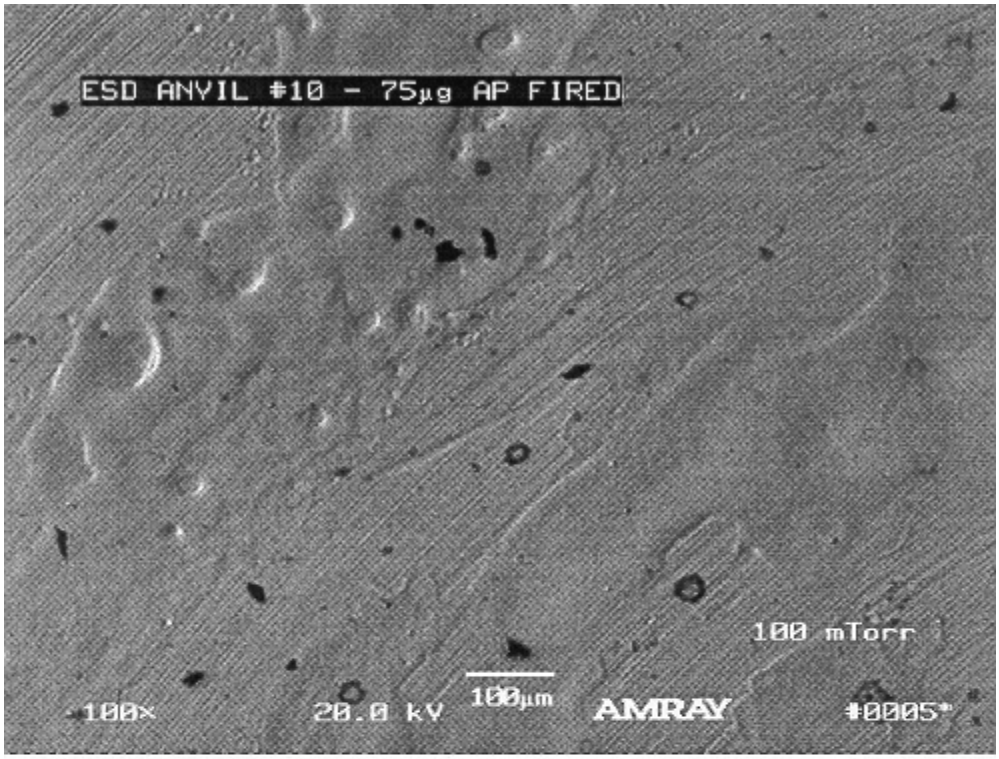
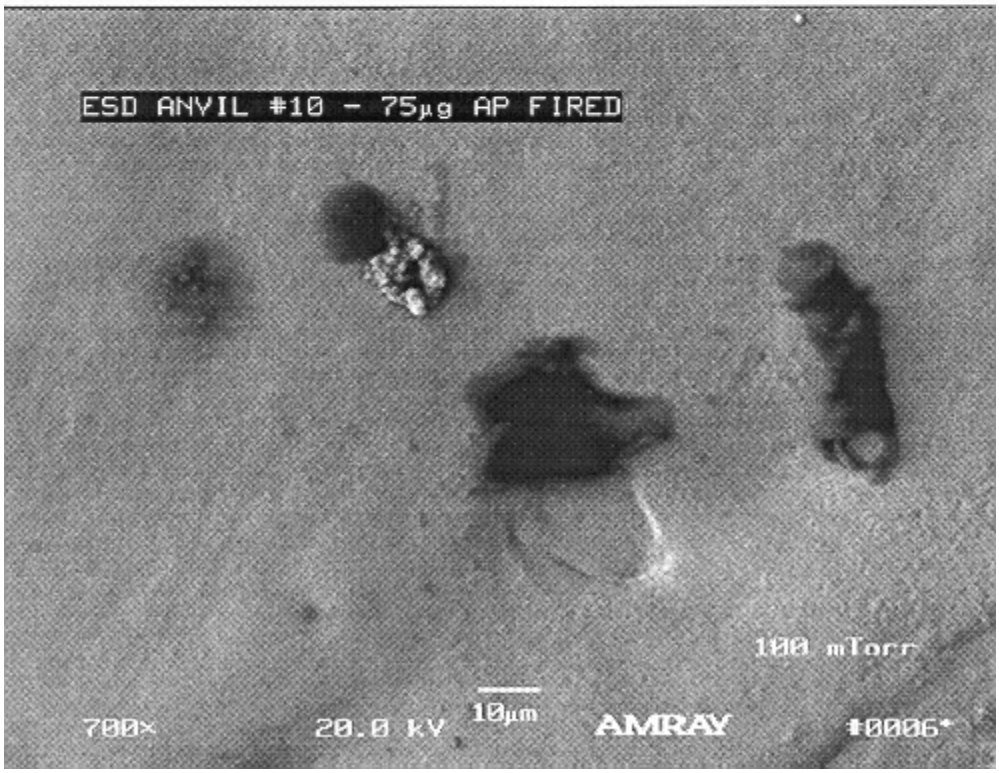
100 mTorr
1mm
13.0× 20.0 kV AMRAY #0001*


ESD ANVIL #15 - 75µg TNT FIRED
100 mTorr
1mm
13.0× 20.0 kV AMRAY #0001*

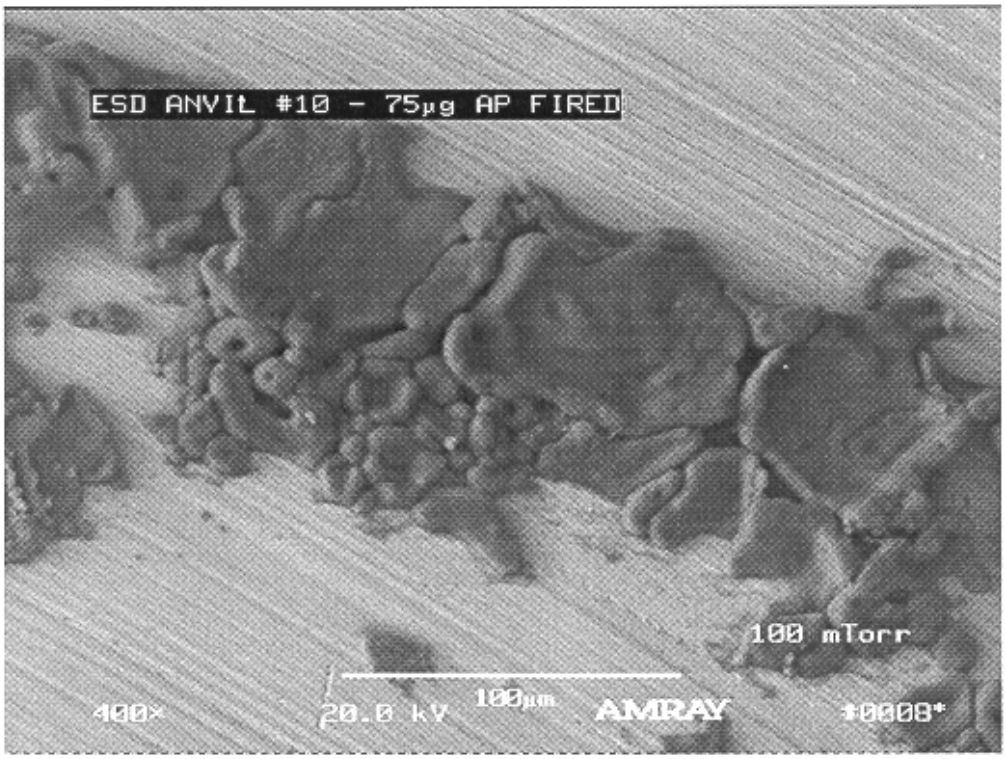

ESD ANVIL #9 - 75µg AP UNFIRED
100 mTorr
150×
20.0 kV
100µm
AMRAY
#0001*


ESD ANVIL #9 - 75µg AP UNFIRED
100 mTorr
20.0 kV
100µm
AMRAY
#0002*


ESD ANVIL #10 - 75µg AP FIRED
100 mTorr
100×
20.0 kV
100µm
AMRAY
#0005*


ESD ANVIL #10 - 75µg AP FIRED
100 mTorr
700×
20.0 kV
10µm
AMRAY
#0006*


ESD ANVIL #10 - 75µg AP FIRED
100 mTorr
AMRAY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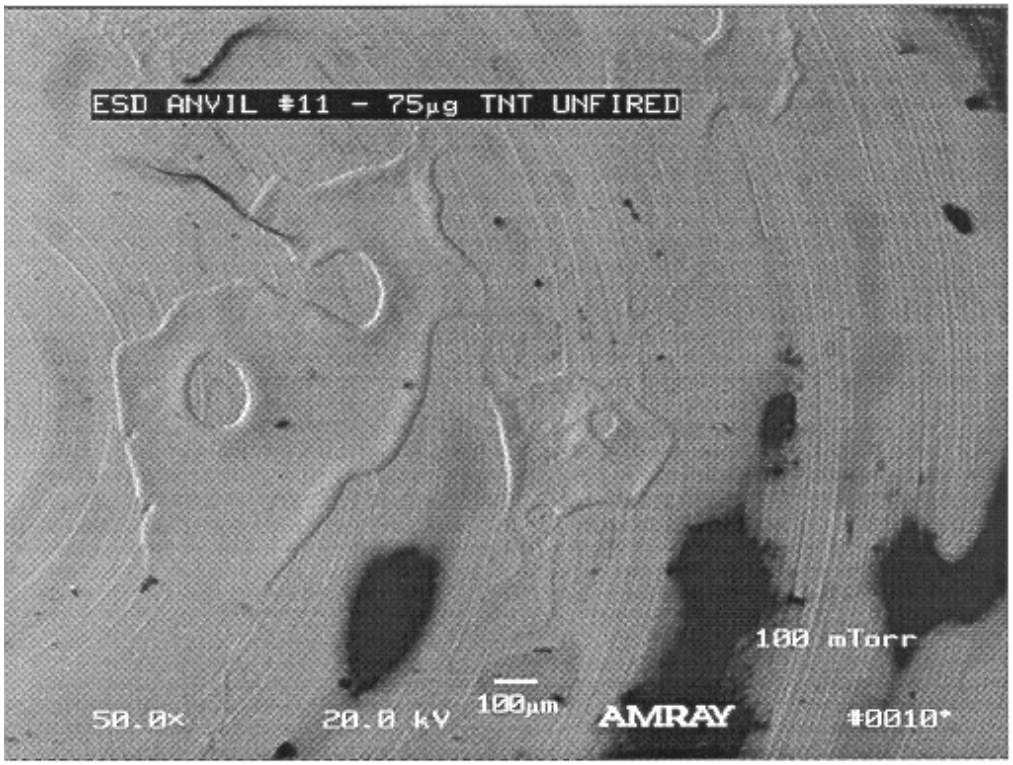
100 mTorr
400×
20.0 kV
100µm
AMRAY
#0008*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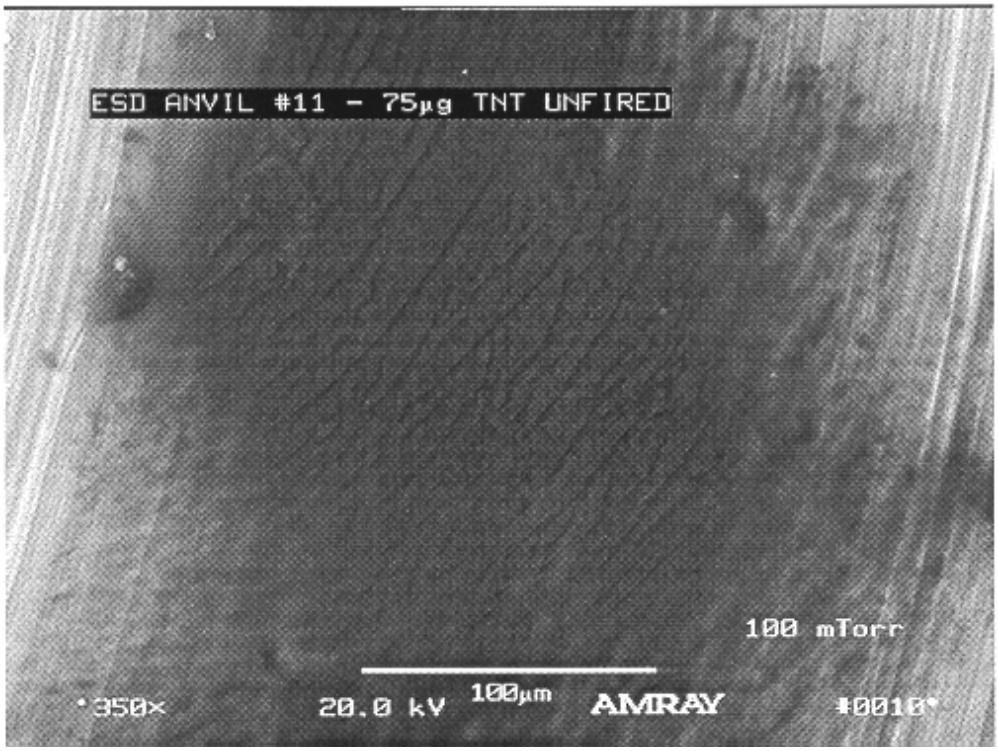
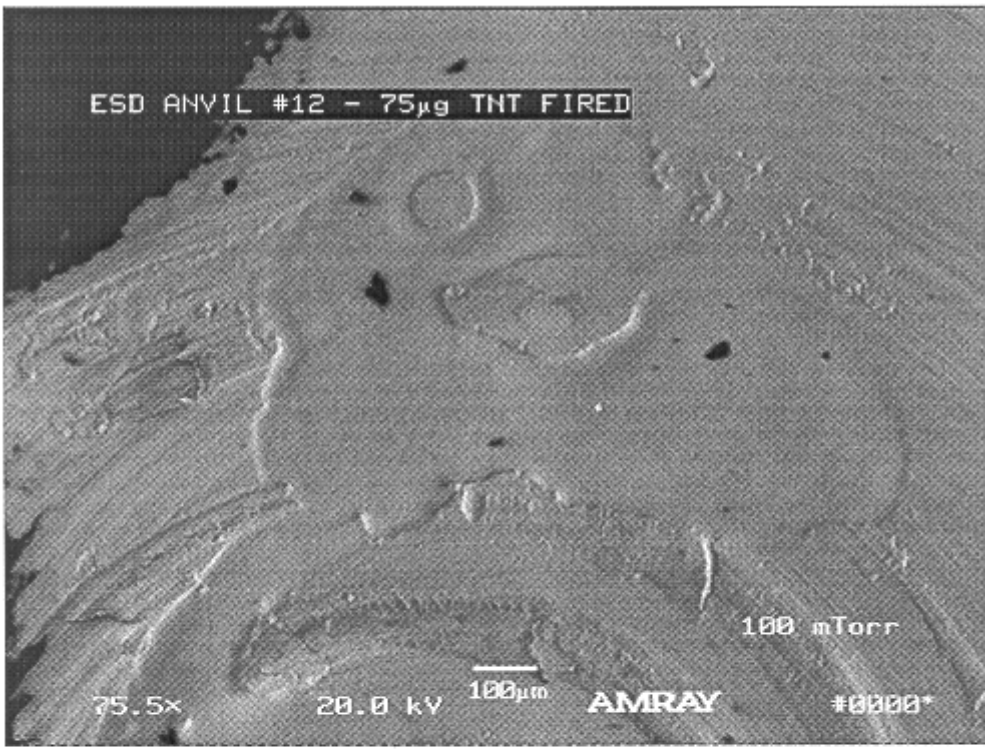
100 mTorr
50.0×
20.0 kV
100µm
AMRAY
#0010*


ESD ANVIL #11 - 75µg TNT UNFIRED
100 mTorr
*350×
20.0 kV
100µm
AMRAY
#0010*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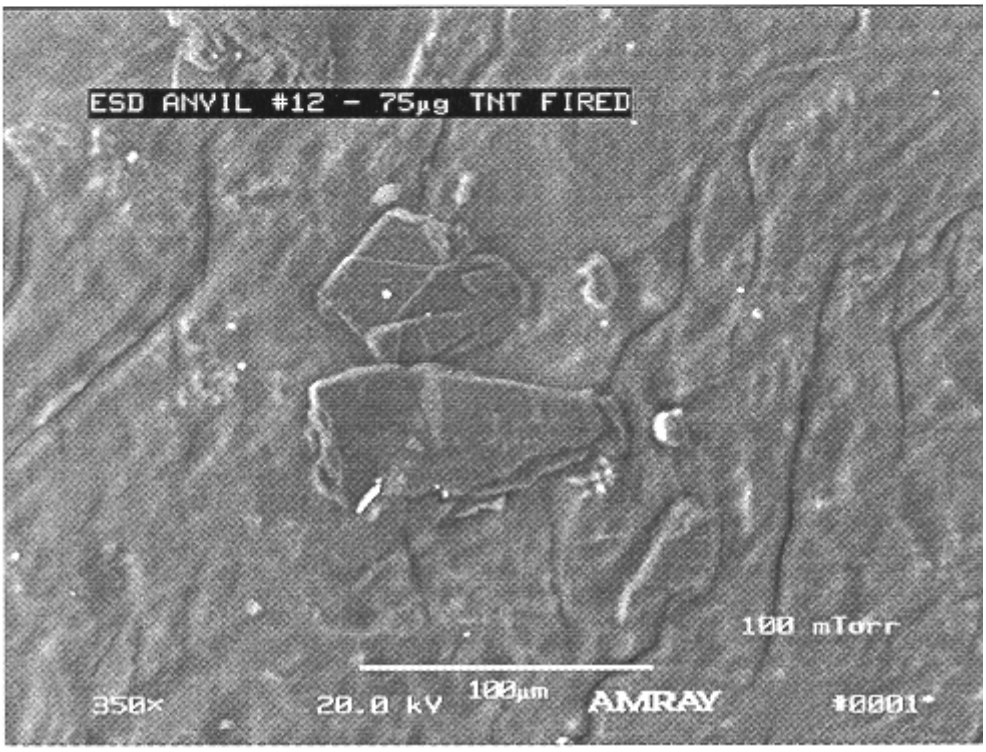
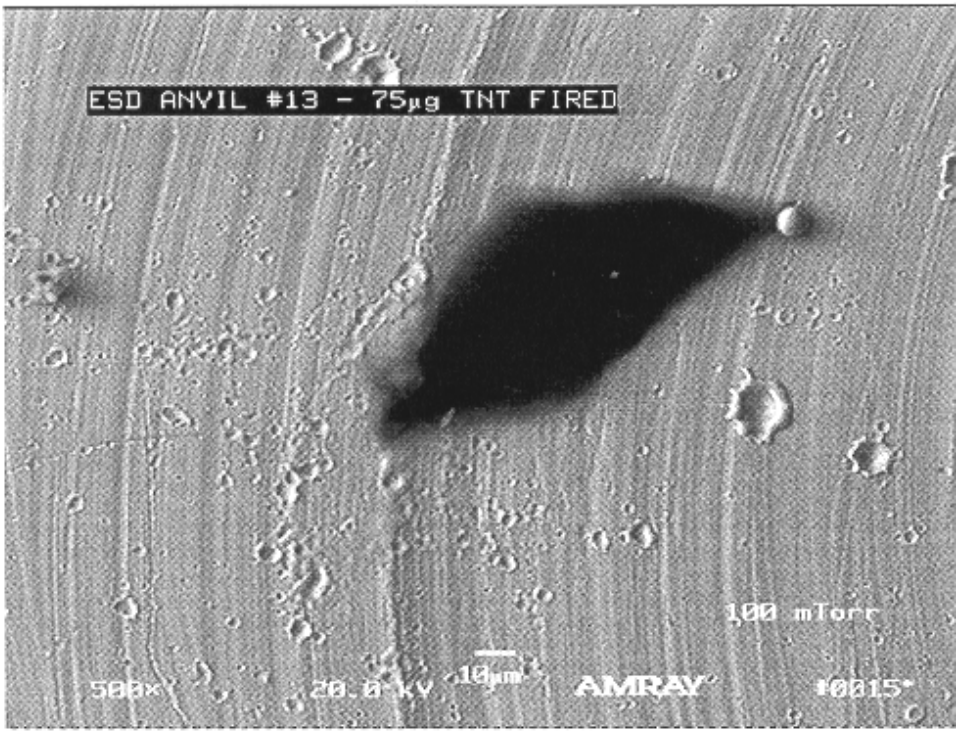
75.5×
20.0 kV
100µm
AMRAY
#0000*

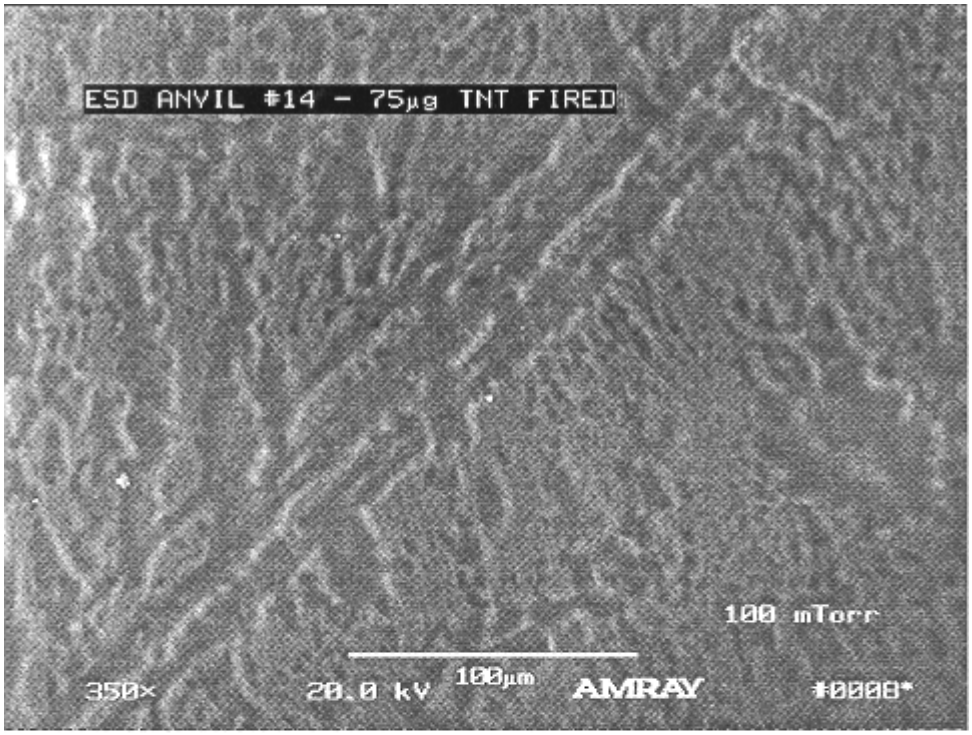

ESD ANVIL #12 - 75µg TNT FIRED
100 mTorr
350×
20.0 kV
100µm
AMRAY
#0001*


ESD ANVIL #13 - 75µg TNT FIRED
100 mTorr
13.0×
20.0 kV
1mm
AMRAY
#0014*


ESD ANVIL #13 - 75µg TNT FIRED
100 mTorr
500×
20.0 kV
10µm
AMRAY
#0015*


ESD ANVIL #14 - 75µg TNT FIRED
100 mTorr
50.0×
20.0 kV
100µm
AMRAY
#0007*


ESD ANVIL #14 - 75µg TNT FIRED
100 mTorr
750×
20.0 kV
10µm
AMRAY
#0009*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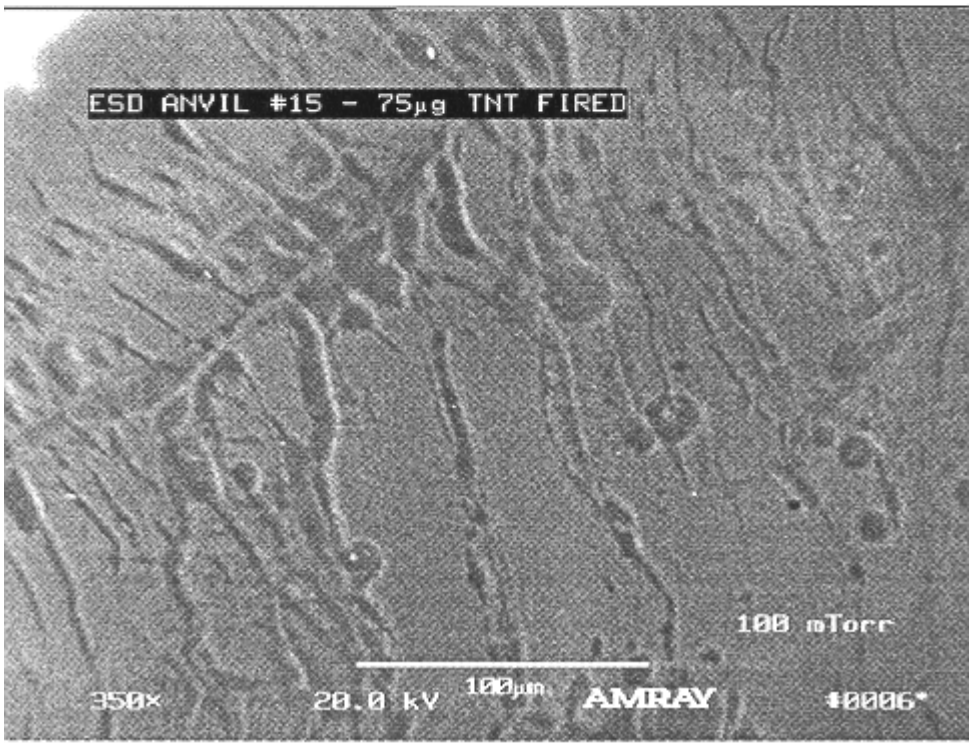
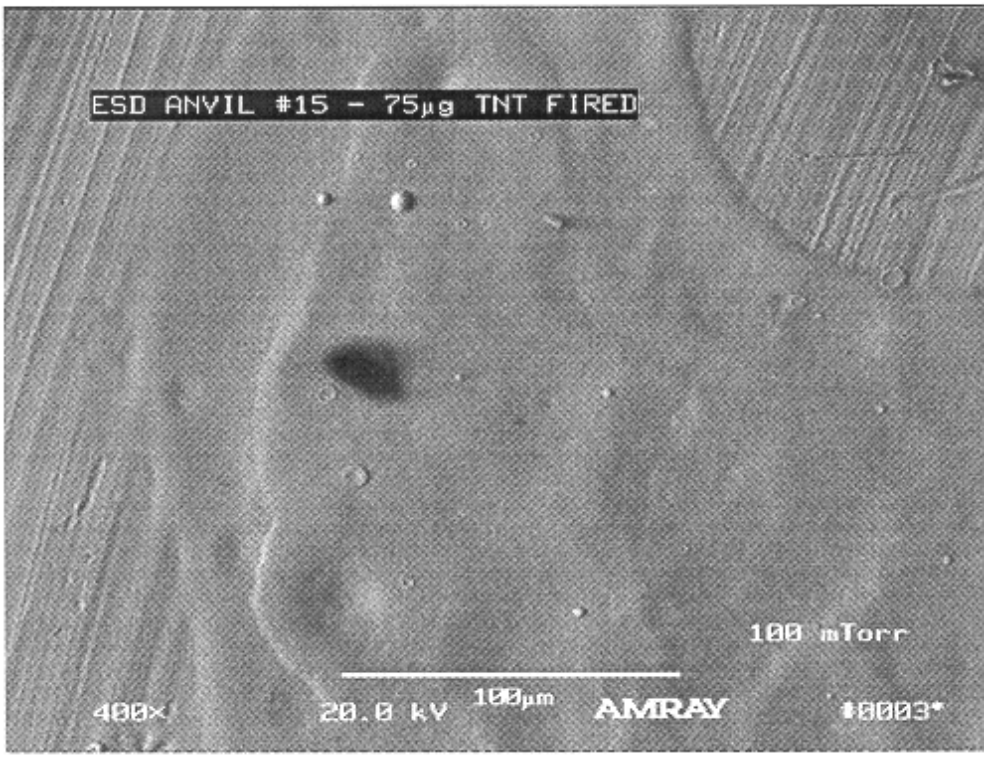
100 mTorr
350×
20.0 kV
100µm
AMRAY
#0008*


ESD ANVIL #15 - 75µg TNT FIRED
100 mTorr
350×
20.0 kV
100µm
AMRAY
#0006*


ESD ANVIL #15 - 75µg TNT FIRED
100 mTorr
20.0 kV
100µm
AMRAY
#0004*


ESD ANVIL #15 - 75µg TNT FIRED
100 mTorr
1,000×
20.0 kV
10µm
AMRAY
#0005*


ESD ANVIL #15 - 75µg TNT FIRED
100 mTorr
50.0× 20.0 kV 100µm AMRAY #0002*


ESD ANVIL #15 - 75µg TNT FIRED
100 mTorr
400× 20.0 kV 100µm AMRAY #0003*

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Appendix L

LEVELS OF ENERGETIC MATERIAL RECOVERED FROM ANVILS

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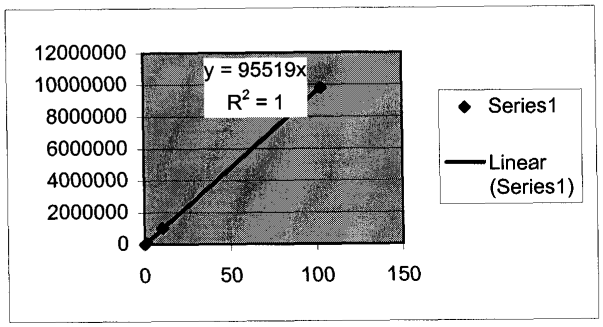
AP RESULTS

Calibration standards

amt.	area
102.6	9795896
10.26	1022799
1.026	109870
0.1026	12393



Method spikes showing recovery

spike amt.	method % recovery
75	88.3
75	87.2
50	68.3
50	72.4

Anvil data

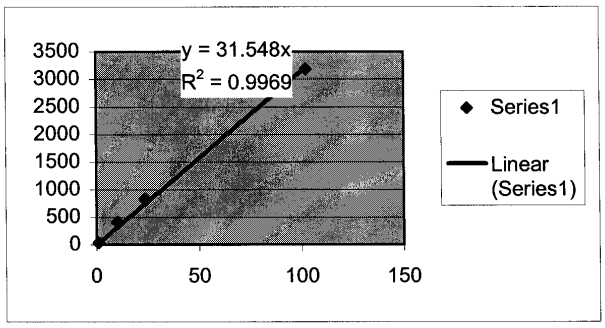
anvil #	% recovery	
3	15.8	Recovery from 50 mic
3-B	9.4	
4	1.6	Recovery from 50 mic visibly reacted anvil
9	22.0	Recovery from 75 mic
9-B	12.4	
10	7.1	Recovery from 75 mic visibly reacted anvil

ENCLOSURE 3

TNT RESULTS

Calibration standards

amt.	area
10.2	417.86
1.02	34.82
23.6	835.33
102	3187.23



Method spikes showing recovery

spike amt.	method % recovery
50	91.0
50	97.0

Anvil data

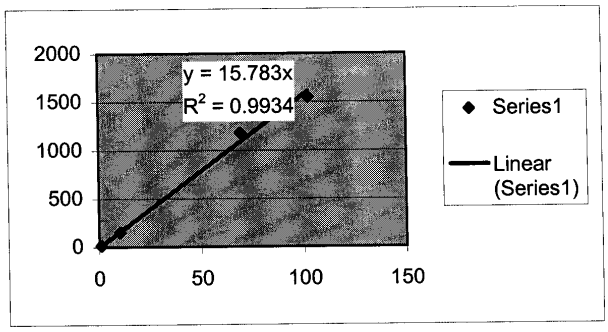
anvil #	% recovery	
5	17.4	Recovery from 50 mic
5-B	23.7	
5-C	3.7	
6	2.5	Recovery from 50 mic visibly reacted anvil
11	6.2	Recovery from 75 mic
11-B	5.3	
11-C	18.7	
13	12.1	Recovery from 75 mic visibly reacted anvil

ENCLOSURE 3

RDX RESULTS

Calibration standards

amt.	area
10.2	154.18
1.02	16.52
69.16	1179.56
102	1550.89



Method spikes showing recovery

spike amt.	method % recovery
75	96.2
75	92.8
50	96.4
50	96.7

Anvil data

anvil #	% recovery	
1	25.1	Recovery from 50 mic
1-B	33.3	
1-C	33.0	
2	28.5	Recovery from 50 mic visibly reacted anvil
7	31.4	Recovery from 75 mic
7-A	34.5	
7-B	34.6	
8	31.9	Recovery from 75 mic visibly reacted anvil

ENCLOSURE

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Appendix B

IHTR 2373

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Indian Head Division
Naval Surface Warfare Center
Indian Head, MD 20640-5035

IHTR 2373
31 August 2001

SENSITIVITY TESTING OF CONTAMINATED SURFACES TO ESTABLISH NON-REACTIVITY LEVELS OF HMX, TATB, HBNQ, NC, AND TETRYL ON WOOD, CONCRETE, AND METAL

Anne E. H. Caris

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

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SENSITIVITY TESTING OF CONTAMINATED SURFACES TO ESTABLISH NON-REACTIVITY LEVELS OF HMX, TATB, HBNQ, NC, AND TETRYL ON WOOD, CONCRETE, AND METAL

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5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Anne E. H. Caris

5d. PROJECT NUMBER

5e. TASK NUMBER

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

The downsizing and closing of military establishments have generated the need to eliminate potential hazards from facilities previously used to process energetic materials. Testing for contamination levels is an established practice; however, there are no established criteria for safe and acceptable levels of contamination of facilities.

Small-scale sensitivity testing was performed to establish levels of contamination that would not exhibit reactions to normally executed construction practices. Standard friction, impact, and electrostatic discharge (ESD) sensitivity tests were used. Wood, concrete, and metal anvils and plates were prepared with a quantifiable amount of contaminant on the testing surfaces. The contaminants were HMX, TATB, HBNQ, NC, and tetryl. Results are given.

15. SUBJECT TERMS

Sensitivity testing	HBNQ
HMX	Nitrocellulose
TATB	Tetryl

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Susan Simpson
U	U	U	SAR	33	19b. TELEPHONE NUMBER (Include area code) (301) 744-4284

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FOREWORD

This report is an adjunct to IHTR 2269, which addressed the explosive contamination levels to which surfaces needed to be cleaned before being released for unrestricted use per DOD 6055.1. This report deals with five additional energetic materials—HMX, TATB, HBNQ, NC, and tetryl. Also, the three original energetic materials, TNT, RDX, and AP, were tested for sensitivity on wood surfaces at the 750-μg/cm^2 level. This report should be used in concert with IHTR 2269.

This work was performed at the Indian Head Division, Naval Surface Warfare Center.

Joseph D. Anderson
Manager, Facilities Modernization Branch

Approved by:

Raymond A. Geckle
Director, Cast Products Technology Division

Released by:

N. Bertucci
Head, Applied Technology Department

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CONTENTS

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BACKGROUND

The downsizing and closing of military establishments have generated the need to eliminate potential hazards from facilities previously used to process energetic materials. Testing for contamination levels is an established practice; however, there are no established criteria for safe and acceptable levels of contamination of facilities.

To establish levels of contamination with appropriate safety factors that could be shown not to exhibit reactions to normally executed construction practices, such as equipment installation and facility remodeling, small-scale sensitivity testing was performed. Wood, concrete, and metal anvils and plates were prepared for use in the sensitivity equipment and then coated with a quantifiable amount of contaminant on the testing surface. These plates and anvils were then subjected to impact, friction, and electrostatic discharge (ESD) sensitivity testing and observed for reactions to the stimuli.

IHTR 2269, *Sensitivity Testing of Contaminated Surfaces to Establish Non-Reactivity Levels of Ammonium Perchlorate, Cyclotrimethylenetrinitramine, and Trinitrotoluene on Wood, Concrete, and Metal,* 30 June 2000, reported on previous testing with AP, RDX, and TNT. This report gives results of testing with five additional materials—HMX (cyclotetramethylenetetranitramine), TATB (triaminotrinitrobenzene), HBNQ (high-bulk-density nitroguanidine), NC (nitrocellulose), and tetryl (trinitrophenylmethylnitramine). Also reported is the sensitivity of the three original materials on wood surfaces at the 750-μg/cm^2 level.

APPROACH

We used several time-honored sensitivity tests for the hazard classification of energetic materials:

- Naval Ordnance Station (NOS) Impact Test
- Alleghany Ballistic Lab (ABL) Friction Test
- ABL Electrostatic Discharge test

These tests cover the gamut of stimuli expected to be experienced during the demolition/decontamination effort.

The procedures for these tests are well defined including the assembly of the test apparatus and preparation of the specimen to be tested. The anvils/plates reflected the surfaces expected to be encountered—metal, wood, or concrete. To determine the level to which contaminated surfaces must be cleaned, plates/anvils containing increasing quantities of the energetic material were tested on the above apparatus until a "reaction" was achieved. The level to which a surface must be cleaned was the next lowest level and one in which no reaction was achieved. Since friction is the stimulus to be experienced most often, the maximum pressure of 980 psig was assigned to depict the "worst case" situation.

To assure consistent and accurate deposition on the plates/anvils, the energetic materials were dissolved in an appropriate solvent to a specified concentration. A pipette was used to apply the energetic material to the surface.

Directions for sample preparation and testing were communicated to the laboratories via action memoranda (Appendix A).

DISCUSSION OF RESULTS

1. The results as reported by the laboratories (Appendix B) are straightforward and confirm engineering analysis of on-site evaluations. However, one anomaly occurred in the HMX series. The 200-$\mu g/cm^2$ sample reacted on the steel anvil while the 500-$\mu g/cm^2$ sample did not. This anomaly dictated a retest of the HMX series especially since the RDX series exhibited reactions on steel at 100 $\mu g/cm^2$ with no reaction at 75 $\mu g/cm^2$.

2. All the contaminants presented "no reaction" at concentrations up to and including 750 $\mu g/cm^2$ on wood and concrete in the friction and impact tests.

3. All concentrations (50, 75, 100 $\mu g/cm^2$) had at least one reaction to ESD. Examination of the anvils/plates indicated only a minimal reaction.

4. Review of Appendix E of IHTR 2269 demonstrates "no reactions" at pressures below 980 psig on RDX. This supports the contention that 980 psig represents the "worse case" situation.

5. Post-test inspections of the concrete-filled friction plates and raw test data indicated that the concrete did not hold up to the friction wheel testing set at 980-psig pressure. Further evaluation of material preparation is necessary. It is reasonable to use the non-reactive levels reported on the steel friction plates for clearance.

CONCLUSIONS

1. Structure surfaces need to be cleaned/decontaminated to 750 μg/cm^2 or less. Steel surfaces (equipment) must be cleaned to 500 μg/cm^2 or less.

2. To preclude initiation by ESD, all hands must be "grounded" in the mode specified in ordnance industry safety manuals—conductive shoes/ground straps, cotton clothing, etc.

3. The HMX friction series was repeated with reactions at 100, 200 and 500 μg/cm^2 per Memorandum Report No. 3 (Appendix B). This validated the original no-reaction levels of 50 and 75 μg/cm^2.

Appendix A

ACTION MEMORANDA

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ACTION MEMORANDUM NO. 1

To: Laura Tinsley 3320J
From: Anne Caris 2150K

Subj: Test Sample Preparation, Request for

1. Please prepare the plates and anvils provided with the energetics listed below by applying the required quantity of solution (solvent as indicated) to realize the level of contamination listed.

2. Please provide a copy of your calculations of solution concentrations and quantity of solution to be applied for each contaminant level.

Table 1. Required contamination

Contaminant	Contaminant level	Substrates	Test
HMX-Acetonitrile	50 µg/cm^2	1 metal plate	friction
	75 µg/cm^2	1 metal plate	friction
	100 µg/cm^2	1 metal plate	friction
	200 µg/cm^2	1 metal plate, 1 wood plate, 1 concrete plate	friction
	500 µg/cm^2	1 metal plate, 1 wood plate, 1 concrete plate	friction
	750 µg/cm^2	1 wood plate, 1 concrete plate	friction
	200 µg/cm^2	1 metal anvil, 1 concrete anvil, 1 wood anvil	impact
	500 µg/cm^2	1 metal anvil, 1 concrete anvil, 1 wood anvil	impact
	750 µg/cm^2	1 metal anvil, 1 concrete anvil, 1 wood anvil	impact
	50 µg/cm^2	20 metal anvils	ESD
	75 µg/cm^2	20 metal anvils	ESD
	100 µg/cm^2	20 metal anvils	ESD
HBNQ-Water	50 µg/cm^2	1 metal plate	friction
	75 µg/cm^2	1 metal plate	friction
	100 µg/cm^2	1 metal plate	friction
	200 µg/cm^2	1 metal plate, 1 wood plate, 1 concrete plate	friction
	500 µg/cm^2	1 metal plate, 1 wood plate, 1 concrete plate	friction
	750 µg/cm^2	1 wood plate, 1 concrete plate	friction
	200 µg/cm^2	1 metal anvil, 1 concrete anvil, 1 wood anvil	impact
	500 µg/cm^2	1 metal anvil, 1 concrete anvil, 1 wood anvil	impact
	750 µg/cm^2	1 metal anvil, 1 concrete anvil, 1 wood anvil	impact
	50 µg/cm^2	20 metal anvils	ESD
	75 µg/cm^2	20 metal anvils	ESD
	100 µg/cm^2	20 metal anvils	ESD

NC-Tetrahydra Furan	50 µg/cm^2 75 µg/cm^2 100 µg/cm^2 200 µg/cm^2 500 µg/cm^2 750 µg/cm^2 200 µg/cm^2 500 µg/cm^2 750 µg/cm^2 50 µg/cm^2 75 µg/cm^2 100 µg/cm^2	1 metal plate 1 metal plate 1 metal plate 1 metal plate, 1 wood plate, 1 concrete plate 1 metal plate, 1 wood plate, 1 concrete plate 1 wood plate, 1 concrete plate 1 metal anvil, 1 concrete anvil, 1 wood anvil 1 metal anvil, 1 concrete anvil, 1 wood anvil 1 metal anvil, 1 concrete anvil, 1 wood anvil 20 metal anvils 20 metal anvils 20 metal anvils	friction friction friction friction friction friction impact impact impact ESD ESD ESD
TATB-Dimethyl Formamide	50 µg/cm^2 75 µg/cm^2 100 µg/cm^2 200 µg/cm^2 500 µg/cm^2 750 µg/cm^2 200 µg/cm^2 500 µg/cm^2 750 µg/cm^2 50 µg/cm^2 75 µg/cm^2 100 µg/cm^2	1 metal plate 1 metal plate 1 metal plate 1 metal plate, 1 wood plate, 1 concrete plate 1 metal plate, 1 wood plate, 1 concrete plate 1 wood plate, 1 concrete plate 1 metal anvil, 1 concrete anvil, 1 wood anvil 1 metal anvil, 1 concrete anvil, 1 wood anvil 1 metal anvil, 1 concrete anvil, 1 wood anvil 20 metal anvils 20 metal anvils 20 metal anvils	friction friction friction friction friction friction impact impact impact ESD ESD ESD
Tetryl-Acetonitrile	50 µg/cm^2 75 µg/cm^2 100 µg/cm^2 200 µg/cm^2 500 µg/cm^2 750 µg/cm^2 200 µg/cm^2 500 µg/cm^2 750 µg/cm^2 50 µg/cm^2 75 µg/cm^2 100 µg/cm^2	1 metal plate 1 metal plate 1 metal plate 1 metal plate, 1 wood plate, 1 concrete plate 1 metal plate, 1 wood plate, 1 concrete plate 1 wood plate, 1 concrete plate 1 metal anvil, 1 concrete anvil, 1 wood anvil 1 metal anvil, 1 concrete anvil, 1 wood anvil 1 metal anvil, 1 concrete anvil, 1 wood anvil 20 metal anvils 20 metal anvils 20 metal anvils	friction friction friction friction friction friction impact impact impact ESD ESD ESD
TNT-Acetonitrile	750 µg/cm^2 750 µg/cm^2	1 wood plate 1 metal anvil, 1 concrete anvil, 1 wood anvil	friction impact
RDX-Acetonitrile	750 µg/cm^2 750 µg/cm^2	1 wood plate 1 metal anvil, 1 concrete anvil, 1 wood anvil	friction impact
AP-Water	750 µg/cm^2 750 µg/cm^2	1 wood plate 1 metal anvil, 1 concrete anvil, 1 wood anvil	friction impact

ACTION MEMORANDUM NO. 2

To: Sensitivity Lab
From: Anne Caris 2150K

Subj: Sensitivity Testing, Request for

1. Please perform tests listed in the tables below.

2. The plates and anvils will be delivered pre-contaminated and labeled to level of contaminations.

3. Total number of friction plates to be tested = 58. Total number of impact anvils to be tested = 54. Total number of ESD anvils to be tested = 300.

4. Please provide results per memorandum as soon as possible.

Table 1. Summary of required friction sensitivity tests

Test	Contaminant	Level of contamination	Substrate	Number of friction plates to be tested
Friction	HMX	50 µg/cm^2	metal	1
		75 µg/cm^2	metal	1
		100 µg/cm^2	metal	1
		200 µg/cm^2	wood, concrete, metal	3 = 11
		500 µg/cm^2	wood, concrete, metal	3
		750 µg/cm^2	wood, concrete	2
	TATB	50 µg/cm^2	metal	1
		75 µg/cm^2	metal	1
		100 µg/cm^2	metal	1
		200 µg/cm^2	wood, concrete, metal	3 = 11
		500 µg/cm^2	wood, concrete, metal	3
		750 µg/cm^2	wood, concrete	2
	HBNQ	50 µg/cm^2	metal	1
		75 µg/cm^2	metal	1
		100 µg/cm^2	metal	1
		200 µg/cm^2	wood, concrete, metal	3 = 11
		500 µg/cm^2	wood, concrete, metal	3
		750 µg/cm^2	wood, concrete	2
	NC	50 µg/cm^2	metal	1
		75 µg/cm^2	metal	1
		100 µg/cm^2	metal	1
		200 µg/cm^2	wood, concrete, metal	3 = 11
		500 µg/cm^2	wood, concrete, metal	3
		750 µg/cm^2	wood, concrete	2
	Tetryl	50 µg/cm^2	metal	1
		75 µg/cm^2	metal	1
		100 µg/cm^2	metal	1
		200 µg/cm^2	wood, concrete, metal	3 = 11
		500 µg/cm^2	wood, concrete, metal	3
		750 µg/cm^2	wood, concrete	2
	TNT	750 µg/cm^2	wood	1
	RDX	750 µg/cm^2	wood	1
	AP	750 µg/cm^2	wood	1

Table 2. Summary of required impact sensitivity tests

Test	Contaminant	Level of contamination	Substrate	Number of impact anvils to be tested
Impact	HMX	200 µg/cm^2 500 µg/cm^2 750 µg/cm^2	wood, concrete, metal wood, concrete, metal wood, concrete, metal	3 3 = 9 3
	TATB	200 µg/cm^2 500 µg/cm^2 750 µg/cm^2	wood, concrete, metal wood, concrete, metal wood, concrete, metal	3 3 = 9 3
	HBNQ	200 µg/cm^2 500 µg/cm^2 750 µg/cm^2	wood, concrete, metal wood, concrete, metal wood, concrete, metal	3 3 = 9 3
	NC	200 µg/cm^2 500 µg/cm^2 750 µg/cm^2	wood, concrete, metal wood, concrete, metal wood, concrete, metal	3 3 = 9 3
	Tetryl	200 µg/cm^2 500 µg/cm^2 750 µg/cm^2	wood, concrete, metal wood, concrete, metal wood, concrete, metal	3 3 = 9 3
	TNT	750 µg/cm^2	wood, concrete, metal	3
	RDX	750 µg/cm^2	wood, concrete, metal	3
	AP	750 µg/cm^2	wood, concrete, metal	3

Table 3. Summary of required ESD sensitivity tests

Test	Contaminant	Level of contamination	Substrate	Number of ESD anvils to be tested
ESD	HMX	50 µg/cm^2 75 µg/cm^2 100 µg/cm^2	metal metal metal	20 20 20
	TATB	50 µg/cm^2 75 µg/cm^2 100 µg/cm^2	metal metal metal	20 20 20
	HBNQ	50 µg/cm^2 75 µg/cm^2 100 µg/cm^2	metal metal metal	20 20 20
	NC	50 µg/cm^2 75 µg/cm^2 100 µg/cm^2	metal metal metal	20 20 20
	Tetryl	50 µg/cm^2 75 µg/cm^2 100 µg/cm^2	metal metal metal	20 20 20

4. Address any question regarding this memo to Anne Caris, at ext. 1892 or by email to carisae@ih.navy.mil.

Appendix B

RESULTS MEMORANDA

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MEMORANDUM REPORT NO. 1

To: Anne Caris 2150K
From: Laura Tinsley 3320J

Subj: Calculations to determine amount of standard solution to be applied to each testing surface.

Friction plate surface area = 10 cm x 4 cm = 40 cm^2
Impact anvil surface area = (3.14159) x (3.175/2 cm)^2 = 7.54 cm^2
ESD anvil surface area = (3.14159) x (.3175 cm)^2 = 0.32 cm^2

Contamination levels for friction plates: 50, 75, 100, 200, 750 micrograms per square centimeter
Contamination levels for impact anvils: 200, 500, 750 micrograms per square centimeter
Contamination levels for ESD anvils: 50, 75, 100 micrograms per square centimeter

HBNQ standard solution is 0.01 grams/100 milliliter

for ESD anvil = (50 $\mu g/cm^2$)(0.32 cm^2)= 16 μg

(100 ml/0.01g) = (x/16 μg) X = (16 μg)(100 ml)/(0.01g) = 0.16 ml or 160 μl

= (75 $\mu g/cm^2$)(0.32 cm^2) = 24 μg

(100 ml/0.01g) = (x/24 μg) X = (24 μg)(100 ml)/(0.01g) = 0.24 ml or 240 μl

= (10 $\mu g/cm^2$)(0.32 cm^2) = 32 μg

(100 ml/0.01g) = x/32 μg) X = (32 μg)(100 ml)/(0.01g) = 0.32 ml or 320 μl

for impact anvils = (50 $\mu g/cm^2$)(7.54 cm^2) = 377 μg

(100 ml/0.01g) = (x/377 μg) X = (377 μg)(100 ml)/(0.01g) = 3,770,000 ml or

= (75 $\mu g/cm^2$)(0.32 cm^2) = 24 μg

(100 ml/0.01g) = (x/24 μg) X = (24 μg)(100 ml)/(0.01g) = 0.24 ml or 240 μl

= (100 $\mu g/cm^2$)(0.32 cm^2) = 32 μg

(100 ml/0.01g) = (x/32 μg) X = (32 μg)(100 ml)/(0.01g) = 0.32 ml or 320 μl

TATB standard solution is 0.004 g/100 milliliter

(50 $\mu g/cm^2$)(0.32 cm2)= 16 μg

(100 ml/0.004g) = (x/16 μg) X = (16 μg)(100 ml)/(0.004g) = 0.4 ml or 400 μl

(75 $\mu g/cm^2$)(0.32 cm^2) = 24 μg
(100 ml/0.004g) = (x/24 μg) X = (24 μg)(100 ml)/(0.004g) = 0.6 ml or 600 μl

(100 $\mu g/cm^2$)(0.32 cm^2) = 32 μg

(100 ml/0.004g) = (x/32 μg) X = (32 μg)(100 ml)/(0.004g) = 0.8 ml or 800 μl

MEMORANDUM REPORT NO. 2

To: Anne Caris 2150K
From: Dan Remmers 9410G

Subj: Sensitivity Testing for Contaminated Steel, Wood, and Concrete

Ref: (a) Request by A. Caris, Code 2150K on 16 August 2000.

1. As requested by reference (a), small scale safety testing was performed on concrete, steel, and wood contaminated with HMX, TATB, HBNQ, NC, tetryl, TNT, RDX, and AP. The tests and results are explained below, and the individual test worksheets were provided.

2. ABL Friction

HMX: The 200 $\mu g/cm^2$ concentration on the steel anvil had a positive reaction at 980 psig. All other concentrations on steel (50, 75, 100, 500 $\mu g/cm^2$) had no reactions at 980 psig.

All HMX concentrations on wood anvils (200, 500, 750 $\mu g/cm^2$) had no reactions.

All HMX concentrations on concrete anvils (200, 500, 750 $\mu g/cm^2$) had no reactions.

TATB: All TATB concentrations on steel anvils (50, 75, 100, 200, 500 $\mu g/cm^2$) had no reactions.

All TATB concentrations on wood anvils (200, 500, 750 $\mu g/cm^2$) had no reactions.

All TATB concentrations on concrete anvils (200, 500, 750 $\mu g/cm^2$) had no reactions.

HBNQ: All HBNQ concentrations on steel anvils (50, 75, 100, 200, 500 $\mu g/cm^2$) had no reactions.

All HBNQ concentrations on wood anvils (200, 500, 750 $\mu g/cm^2$) had no reactions.

All HBNQ concentrations on concrete anvils (200, 500, 750 $\mu g/cm^2$) had no reactions.

NC: All NC concentrations on steel anvils (75, 100, 200, 500, 750 $\mu g/cm^2$) had no reactions.

All NC concentrations on wood anvils (200, 500, 750 $\mu g/cm^2$) had no reactions.

All NC concentrations on concrete anvils (200, 500, 750 $\mu g/cm^2$) had no reactions.

tetryl: The 100, 200, and 500 $\mu g/cm^2$ concentrations on steel had a positive reaction at 980 psig. All other concentrations on steel (50, 75 $\mu g/cm^2$) had no reactions at 980 psig.

All tetryl concentrations on wood anvils (200, 500, 750 $\mu g/cm^2$) had no reactions.

All tetryl concentrations on concrete anvils (200, 500, 750 $\mu g/cm^2$) had no reactions.

TNT: 750 $\mu g/cm^2$ on the wood anvil had no reactions.

RDX: 750 $\mu g/cm^2$ on the wood anvil had no reactions.

AP: 750 $\mu g/cm^2$ on the wood anvil had no reactions.

3. NOS Impact

HMX: All HMX concentrations on steel anvils (200, 500, 750 $\mu g/cm^2$) had no reactions at the 1000 mm drop height.

All HMX concentrations on wood anvils (200, 500, 750 $\mu g/cm^2$) had no reactions at the 1000 mm drop height.

All HMX concentrations on concrete anvils (200, 500, 750 $\mu g/cm^2$) had no reactions at the 1000 mm drop height.

TATB: All TATB concentrations on steel anvils (200, 500, 750 $\mu g/cm^2$) had no reactions at the 1000 mm drop height.

All TATB concentrations on wood anvils (200, 500, 750 $\mu g/cm^2$) had no reactions at the 1000 mm drop height.

All TATB concentrations on concrete anvils (200, 500, 750 $\mu g/cm^2$) had no reactions at the 1000 mm drop height.

HBNQ: All HBNQ concentrations on steel anvils (200, 500, 750 $\mu g/cm^2$) had no reactions at the 1000 mm drop height.

All HBNQ concentrations on wood anvils (200, 500, 750 $\mu g/cm^2$) had no reactions at the 1000 mm drop height.

All HBNQ concentrations on concrete anvils (200, 500, 750 $\mu g/cm^2$) had no reactions at the 1000 mm drop height.

NC: The 750 $\mu g/cm^2$ concentration on the steel anvil had a positive reaction at the 1000 mm drop height. All other concentrations on steel (200, 500 $\mu g/cm^2$) had no reactions at the 1000 mm drop height.

All NC concentrations on wood anvils (200, 500, 750 $\mu g/cm^2$) had no reactions at the 1000 mm drop height.

All NC concentrations on concrete anvils (200, 500, 750 $\mu g/cm^2$) had no reactions at the 1000 mm drop height.

tetryl: All tetryl concentrations on steel anvils (200, 500, 750 $\mu g/cm^2$) had no reactions at the 1000 mm drop height.

All tetryl concentrations on wood anvils (200, 500, 750 $\mu g/cm^2$) had no reactions at the 1000 mm drop height.

All tetryl concentrations on concrete anvils (200, 500, 750 $\mu g/cm^2$) had no reactions at the 1000 mm drop height.

TNT: 750 $\mu g/cm^2$ on the steel anvil had no reactions.

750 $\mu g/cm^2$ on the wood anvil had no reactions.

750 $\mu g/cm^2$ on the concrete anvil had no reactions.

RDX: 750 μg/cm^2 on the steel anvil had no reactions.

750 μg/cm^2 on the wood anvil had no reactions.

750 μg/cm^2 on the concrete anvil had no reactions.

AP: 750 μg/cm^2 on the steel anvil had no reactions.

750 μg/cm^2 on the wood anvil had no reactions.

750 μg/cm^2 on the concrete anvil had no reactions.

4. ABL Electrostatic Discharge

All concentrations (50, 75, 100 μg/cm^2) of all contaminants had at least one reaction to electrostatic discharge. The individual test sheets were provided, along with a list of the pin number and the reaction. The NC contaminated pins were retested.

5. The tests were completed on November 2, 2000. Testing was conducted at NSWC Indian Head, in the Hazard Characterization Lab, Building 888. If there are any questions, please call the Hazard Characterization Group at 301-744-4109 or send a FAX at 301-744-4116.

Daniel Remmers
Hazard Characterization Group

5100
Ser 9410G/16/dr
21 February 2001

MEMORANDUM

To: Anne Caris 2150K
From: Dan Remmers 9410G

Subj: SENSITIVITY TESTING FOR HMX CONTAMINATED STEEL

Ref: (a) Request by A. Caris, Code 2150K on 6 February 2001.

1. As requested by reference (a), ABL friction testing was performed on steel contaminated with HMX. The concentrations provided were 200 and 500 $\mu g/cm^2$.

2. Both the 200 and 500 $\mu g/cm^2$ concentrations on the steel anvil had positive reactions at 980 psig. The individual worksheets are attached.

3. The tests were completed on February 13, 2001. Testing was conducted at NSWC Indian Head, in the Hazard Characterization Lab, Building 888. If there are any questions, please call the Hazard Characterization Group at 301-744-4109 or send a FAX at 301-744-4116.

Daniel Remmers
Hazard Characterization Group

ABL FRICTION TEST

sample name: HMX contaminated steel
sample ID: 200 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson

date: 2/13/01
temperature: 29 °C
relative humidity: 30 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980	1	1																			yellow sparks
750																					
560																					
420																					
315																					
235																					
180																					
135																					
100																					
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: 0 psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvils, in building 888 room 104

ABL FRICTION TEST

sample name: HMX contaminated steel
sample ID: 500 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Chesley

date: 2/13/01
temperature: 29 °C
relative humidity: 30 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980	1																				orange sparks
750																					
560																					
420																					
315																					
235																					
180																					
135																					
100																					
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: 0 psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvils, in building 888 room 104

5100
Ser 9410G/21/dr
12 March 2001

MEMORANDUM

To: Anne Caris 2150K
From: Dan Remmers 9410G

Subj: SENSITIVITY TESTING FOR HMX CONTAMINATED STEEL

Ref: (a) Requests by A. Caris, Code 2150K on 23 February 2001.

1. As requested by reference (a), ABL friction testing was performed on steel contaminated with HMX. The concentrations provided were 100 and 150 $\mu g/cm^2$.

2. Both the 100 and 150 $\mu g/cm^2$ concentrations on the steel anvil had positive reactions at 980 psig. The individual worksheets are attached.

3. The tests were completed on February 28, 2001. Testing was conducted at NSWC Indian Head, in the Hazard Characterization Lab, Building 888. If there are any questions, please call the Hazard Characterization Group at 301-744-4109 or send a FAX at 301-744-4116.

Daniel Remmers
Hazard Characterization Group

ABL FRICTION TEST

sample name: HMX contaminated steel
sample ID: 100 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson

date: 2/28/01
temperature: 28 °C
relative humidity: 31 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980	0	1																			spark
750																					
560																					
420																					
315																					
235																					
180																					
135																					
100																					
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: **0** psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvils, in building 888 room 104

ABL FRICTION TEST

sample name: HMX contaminated steel
sample ID: 150 µg/cm2
sample prep: residue
requester: Anne Caris, 2150K
operator: T. Tolson

date: 2/28/01
temperature: 28 ℃
relative humidity: 31 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980	1																				sparks
750																					
560																					
420																					
315																					
235																					
180																					
135																					
100																					
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: **0** psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvils, in building 888 room 104

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OE	2
04	1
071	3
073	1
20	1
210	1
2120K	4
2150	4

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Appendix C

TEST PLAN

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Document Number 370/02/109

TEST PLAN
TO
ASSESS THE SENSITIVITY
OF CONTAMINATED SURFACES
TO ESTABLISH
NON-REACTIVITY LEVELS
OF
AMMONIUM PICRATE, TETRYL, NG, NITRONOL, HBNQ, HMX, NC, TATB, TNT, RDX, AND AP
ON
WOOD, CONCRETE, METAL AND TRANSITE

Issuing Activity
Naval Surface Warfare Center
Indian Head Division
Indian Head, Md 20640-5035

TEST PLAN TO ASSESS THE SENSITIVITY LEVELS OF CONTAMINATED SURFACES TO ESTABLISH NON-REACTIVITY LEVELS

Document # 370/02/109

Prepared By

Paul Wallman /Test Coordinator _____

Approved By

Anne Caris, Project Manager _____

TEST PLAN TO ASSESS THE SENSITIVITY LEVELS OF CONTAMINATED SURFACES TO ESTABLISH NON-REACTIVITY LEVELS

Document # 370/02/109

Document Number 370/02/109

1. Introduction

The purpose of these tests is to assess the sensitivity of contaminated surfaces to establish non-reactivity levels of AMMMONIUM PICRATE, TETRYL, NG, NITRONOL, HBNQ, HMX, NC, TATB, TNT, RDX, and AP on wood, concrete, metal and transite.

2. Objectives

The objectives of this testing effort are to:

- Determine the minimum explosive concentration level that will cause a reaction on an impact, friction or ESD machine using various explosives at various contamination levels.

3. Test Methodology

2 metal friction plates will be sent to the analytical laboratory to be contaminated with red dye, HMX and solvent at 200μg/cm^2 and 750μg/cm^2 levels. This will help visualize the uniformity of the contaminates.

3 metal friction plates will be sent to the analytical laboratory to be contaminated with HMX at 50μg/cm^2, 100μg/cm^2 and 500μg/cm^2 levels. These plates will then be tested for uniformity of contamination in different areas of the plate. A mask consisting of five ½" squares will be placed on the plates and samples from each test square will be taken using a swab saturated with a solvent capable of removing the HMX, presumably acetonitrile (ACN). A minimum of three swabs will be used at each test location to ensure complete extraction.

The explosive to be tested will be dissolved in standard solution. The contamination area of the plate, or anvil (test item) will be marked and the surface area calculated. The quantity of solution necessary to deposit the desired contamination level will then be calculated and this amount placed uniformly over the surface of the test item.

Friction plates, impact anvils and ESD anvils with various explosives and at various concentrations will then be contaminated. Once dry, the test items will undergo impact, friction and ESD testing to determine at what concentration there may be a reaction.

Control plates and anvils will be contaminated at various levels and carried around with the test items but not tested. These controls will then be returned to the analytical laboratory to have quantitative analysis performed to check the contamination level. This is to see if degradation of the sample concentration is affected by handling.

4. Test Apparatus and Hardware

4.1. Friction Plates will be made of wood, metal, transite and metal filled with concrete. Figure 4.1 shows a typical friction plate and the area to be contaminated.

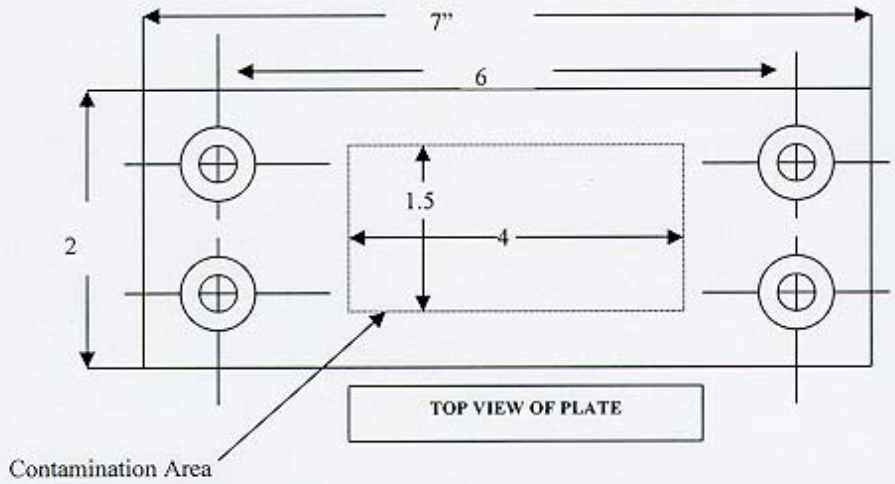
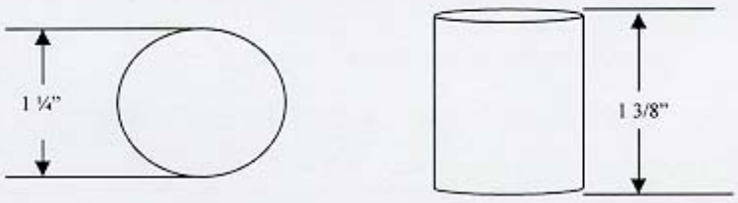


Figure 4.1. Typical Friction Plate

4.2. Impact Anvils will be made of wood, metal, transite and metal filled with concrete. Figure 4.2 shows a typical impact anvil. The whole top of the anvil will be the area of contamination.



TOP VIEW OF ANVIL

SIDE VIEW OF ANVIL

Figure 4.2. Typical Impact Anvil

4.3. ESD Anvils and Holder will be made of metal. Figure 4.3 shows a typical ESD anvil and holder.

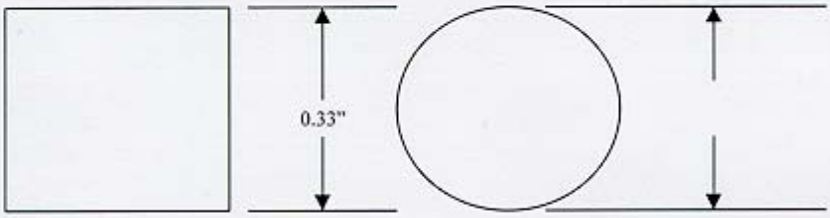


Figure 4.3. Drawing of ESD Anvil

4.4. NOS Impact Tester with a 5 kilogram drop weight, type 12 steel striker, and supplied impact anvils as outlined in table 5.1.

4.5 ABL Friction Tester with steel friction wheel and supplied friction plates as outlined in table 5.1. Plate velocity is 8 feet per second.

4.6 ABL Model 150 Electrostatic Discharge tester, operating at 5.8 kilovolts, with supplied anvils as outlined in table 5.1.

5. Test Articles

Table 5.1 contains the contaminants and the levels to which the item is to be contaminated, the substrate and test required.

Table 5.1. Required contamination

Contaminant	Contaminant Level	Substrates	Test
AMMONIUM PICRATE	50 µg/cm^2	1 metal plate (1 for testing)	friction
	75 µg/cm^2	1 metal plate (1 for testing)	friction
	100 µg/cm^2	1 metal plate (1 for testing)	friction
	200 µg/cm^2	2 metal plate, 2 wood plate, 2 concrete plate, 2 transite plate (1 for testing + 1 for control)	friction
	500 µg/cm^2	1 metal plate, 1 wood plate, 1 concrete plate, 1 transite plate (1 for testing)	friction
	750 µg/cm^2	1 wood plate, 1 concrete plate, 1 transite plate (1 for testing)	friction
	50 µg/cm^2	1 metal anvil (1 for testing)	impact
	75 µg/cm^2	1 metal anvil (1 for testing)	impact
	100 µg/cm^2	1 metal anvil (1 for testing)	impact

	200 µg/cm^2	1 metal anvil, 1 wood anvil, 1 concrete anvil, 1 transite anvil (1 for testing)	impact
	500 µg/cm^2	2 metal anvil, 2 wood anvil, 2 concrete anvil, 2 transite anvil (1 for testing + 1 for control)	impact
	750 µg/cm^2	1 wood anvil, 1 concrete anvil, 1 transite anvil (1 for testing)	impact
	50 µg/cm^2	21 metal anvils (20 for testing + 1 for control)	ESD
	75 µg/cm^2	20 metal anvils (20 for testing)	ESD
	100 µg/cm^2	20 metal anvils (20 for testing)	ESD
TETRYL	200 µg/cm^2	1 transite plate, 1 concrete plate (1 for testing)	friction
	500 µg/cm^2	2 transite plate, 2 concrete plate (1 for testing + 1 for control)	friction
	750 µg/cm^2	1 transite plate, 1 concrete plate (1 for testing)	friction
	200 µg/cm^2	2 transite anvil, 2 concrete anvil (1 for testing + 1 for control)	impact
	500 µg/cm^2	1 transite anvil, 1 concrete anvil (1 for testing)	impact
	750 µg/cm^2	1 transite anvil, 1 concrete anvil (1 for testing)	impact
NG	50 µg/cm^2	1 metal plate (1 for testing)	friction
	75 µg/cm^2	1 metal plate (1 for testing)	friction
	100 µg/cm^2	1 metal plate (1 for testing)	friction
	200 µg/cm^2	1 metal plate, 1 wood plate, 1 concrete plate, 1 transite plate (1 for testing)	friction
	500 µg/cm^2	2 metal plate, 2 wood plate, 2 concrete plate, 2 transite plate (1 for testing + 1 for control)	friction
	750 µg/cm^2	1 wood plate, 1 concrete plate, 1 transite plate (1 for testing)	friction
	50 µg/cm^2	1 metal anvil (1 for testing)	impact
	75 µg/cm^2	1 metal anvil (1 for testing)	impact
	100 µg/cm^2	1 metal anvil (1 for testing)	impact
	200 µg/cm^2	2 metal anvil, 2 wood anvil, 2 concrete anvil, 2 transite anvil (1 for testing + 1 for control)	impact
	500 µg/cm^2	1 metal anvil, 1 wood anvil, 1 concrete anvil, 1 transite anvil (1 for testing)	impact
	750 µg/cm^2	1 wood anvil, 1 concrete anvil, 1 transite anvil (1 for testing)	impact
	50 µg/cm^2	21 metal anvils (20 for testing + 1 for control)	ESD
	75 µg/cm^2	20 metal anvils (20 for testing)	ESD
	100 µg/cm^2	20 metal anvils (20 for testing)	ESD

TEST PLAN TO ASSESS THE SENSITIVITY LEVELS OF CONTAMINATED SURFACES TO ESTABLISH NON-REACTIVITY LEVELS
Document # 370/02/109

Contaminant	Contaminant Level	Substrates	Test
NITRONAL	50 µg/cm^2	1 metal plate (1 for testing)	friction
	75 µg/cm^2	1 metal plate (1 for testing)	friction
	100 µg/cm^2	1 metal plate (1 for testing)	friction
	200 µg/cm^2	1 metal plate, 1 wood plate, 1 concrete plate, 1 transite plate (1 for testing)	friction
	500 µg/cm^2	2 metal plate, 2 wood plate, 2 concrete plate, 2 transite plate (1 for testing + 1 for control)	friction
	750 µg/cm^2	1 wood plate, 1 concrete plate, 1 transite plate (1 for testing)	friction
	50 µg/cm^2	1 metal anvil (1 for testing)	impact
	75 µg/cm^2	1 metal anvil (1 for testing)	impact
	100 µg/cm^2	1 metal anvil (1 for testing)	impact
	200 µg/cm^2	2 metal anvil, 2 wood anvil, 2 concrete anvil, 2 transite anvil (1 for testing + 1 for control)	impact
	500 µg/cm^2	1 metal anvil, 1 wood anvil, 1 concrete anvil, 1 transite anvil (1 for testing)	impact
	750 µg/cm^2	1 wood anvil, 1 concrete anvil, 1 transite anvil (1 for testing)	impact
	50 µg/cm^2	20 metal anvils (20 for testing)	ESD
	75 µg/cm^2	21 metal anvils (20 for testing + 1 for control)	ESD
	100 µg/cm^2	20 metal anvils (20 for testing)	ESD
HBNQ	200 µg/cm^2	2 transite plate, 2 concrete plate (1 for testing + 1 for control)	friction
	500 µg/cm^2	1 transite plate, 1 concrete plate (1 for testing)	friction
	750 µg/cm^2	1 transite plate, 1 concrete plate (1 for testing)	friction
	200 µg/cm^2	1 transite anvil, 1 concrete anvil (1 for testing)	impact
	500 µg/cm^2	2 transite anvil, 2 concrete anvil (1 for testing + 1 for control)	impact
	750 µg/cm^2	1 transite anvil, 1 concrete anvil (1 for testing)	impact
HMX	200 µg/cm^2	1 transite plate, 1 concrete plate (1 for testing)	friction
	500 µg/cm^2	2 transite plate, 2 concrete plate (1 for testing + 1 for control)	friction
	750 µg/cm^2	1 transite plate, 1 concrete plate (1 for testing)	friction
	200 µg/cm^2	1 transite anvil, 1 concrete anvil (1 for testing)	impact
	500 µg/cm^2	1 transite anvil, 1 concrete anvil (1 for testing)	impact
	750 µg/cm^2	2 transite anvil, 2 concrete anvil (1 for testing + 1 for control)	impact

TEST PLAN TO ASSESS THE SENSITIVITY LEVELS OF CONTAMINATED SURFACES TO ESTABLISH NON-REACTIVITY LEVELS
Document # 370/02/109

Contaminant	Contaminant Level	Substrates	Test
NC	200 µg/cm^2	1 transite plate, 1 concrete plate (1 for testing)	friction
	500 µg/cm^2	1 transite plate, 1 concrete plate (1 for testing)	friction
	750 µg/cm^2	2 transite plate, 2 concrete plate (1 for testing + 1 for control)	friction
	200 µg/cm^2	2 transite anvil, 2 concrete anvil (1 for testing + 1 for control)	impact
	500 µg/cm^2	1 transite anvil, 1 concrete anvil (1 for testing)	impact
	750 µg/cm^2	1 transite anvil, 1 concrete anvil (1 for testing)	impact
TATB	200 µg/cm^2	2 transite plate, 2 concrete plate (1 for testing + 1 for control)	friction
	500 µg/cm^2	1 transite plate, 1 concrete plate (1 for testing)	friction
	750 µg/cm^2	1 transite plate, 1 concrete plate (1 for testing)	friction
	200 µg/cm^2	1 transite anvil, 1 concrete anvil (1 for testing)	impact
	500 µg/cm^2	2 transite anvil, 2 concrete anvil (1 for testing + 1 for control)	impact
	750 µg/cm^2	1 transite anvil, 1 concrete anvil (1 for testing)	impact
TNT	200 µg/cm^2	2 transite plate (1 for testing + 1 for control)	friction
	500 µg/cm^2	1 transite plate (1 for testing)	friction
	750 µg/cm^2	1 transite plate (1 for testing)	friction
	200 µg/cm^2	2 transite anvil (1 for testing + 1 for control)	impact
	500 µg/cm^2	1 transite anvil (1 for testing)	impact
	750 µg/cm^2	1 transite anvil (1 for testing)	impact
RDX	200 µg/cm^2	1 transite plate (1 for testing)	friction
	500 µg/cm^2	2 transite plate (1 for testing + 1 for control)	friction
	750 µg/cm^2	1 transite plate (1 for testing)	friction
	200 µg/cm^2	1 transite anvil (1 for testing)	impact
	500 µg/cm^2	2 transite anvil (1 for testing + 1 for control)	impact
	750 µg/cm^2	1 transite anvil (1 for testing)	impact
AP	200 µg/cm^2	1 transite plate (1 for testing)	friction
	500 µg/cm^2	1 transite plate (1 for testing)	friction
	750 µg/cm^2	2 transite plate (1 for testing + 1 for control)	friction
	200 µg/cm^2	1 transite anvil (1 for testing)	impact
	500 µg/cm^2	1 transite anvil (1 for testing)	impact
	750 µg/cm^2	2 transite anvil (1 for testing + 1 for control)	impact

6. Pre-Test Inspections and Preparation.

6.1 Pre-Test Photographs – digital images of all the contaminated plates and anvils will be taken for documentation purposes.

6.2 Visually inspect all test items after contamination and before testing.

7. Test Procedure for Contamination of plates and anvils

7.1 The goal in contaminating the plates and anvils is to contaminate at the testing level requirement in a uniform fashion. To achieve this goal, a solvent containing the explosive is spread over the surface to be contaminated. When the solvent evaporates, the surface is contaminated with the explosive at the appropriate level. A micropipette is used to dispense the exact amount of explosive solution needed to contaminate the surface. The pates and anvils are allowed to air-dry in the chemical hood.

7.2 The two criteria for selecting a solvent are how well the explosive dissolves in it and how quickly it evaporates. Crystals of explosive will tend to form around a seed crystal. It is anticipated that concentrated solutions that evaporate quickly will result in more seed crystals and therefore a more even distribution of explosive on the surface.

7.3 Plates and anvils are rejected if the explosive solution runs outside of the contamination area. If this occurs, the plate or anvil is cleaned and recontaminated.

8. Test Procedure for Impact Friction and ESD Tests

8.1 Impact Test Procedure

SOP P30981 is the procedure used to test materials on the NOS Impact tester. Procedures specific to this test plan are as follows:

8.1.1 Replace the standard steel anvil with the supplied contaminated anvil to be tested.

8.1.2 Place the standard steel striker on the anvil and drop the weight from 1000 millimeters.

8.1.3 Record any of the following as a positive reaction: sparks, flame, smoke, noise beyond ambient impact noise, burn marks, charring. Record the type of reaction when a positive occurs.

8.1.4 If a negative reaction occurs, repeat steps 8.1.2 and 8.1.3 until 10 negative reactions are recorded.

8.1.5 After the test, remove but do not clean the anvil.

8.2 Friction Test Procedure

SOP P30979 is the procedure used to test materials on the ABL Friction tester. Procedures specific to this test plan are as follows:

8.2.1 Replace the standard steel friction plate with the supplied contaminated plate to be tested.

8.2.2 Lower the steel wheel onto an untested and contaminated area of the plate and pump the pressure to 980 psig.

8.2.3 Drop the pendulum from the 8 feet per second position.

8.2.4 Record any of the following as a positive reaction: sparks, flame, smoke, noise beyond ambient friction noise, burn marks, charring. Record the type of reaction when a positive occurs.

8.2.5 If a negative reaction occurs, repeat steps 8.2.2 through 8.2.4 until 20 negative reactions are recorded.

8.2.6 After the test, remove but do not clean the plate.

8.3 ESD Test Procedure

SOP P30995 is the procedure used to test materials on the ABL Electrostatic Discharge tester. Procedures specific to this test plan are as follows:

8.3.1 Instead of the standard sample holder, use the supplied sample holder that has removable anvils.

8.3.2 Place an untested contaminated ESD anvil into the sample holder and place the sample in the tester.

8.3.3 Charge the 0.5 microfarad capacitor (8.33 joules) and discharge the spark into the sample.

8.3.4 Record any of the following as a positive reaction: sparks or flame beyond ambient spark discharge, smoke, noise beyond ambient spark discharge, burn marks, charring. Record the type of reaction when a positive occurs.

8.3.5 If a positive occurs proceed to the next higher sensitivity level.

8.3.6 Repeat steps 8.3.2 through 8.3.4 until all 20 anvils are tested.

9. Test Procedure for Quantitative Analysis

9.1 Several different control test items will be contaminated and walked through all the procedural steps without being subjected to any testing. These control test items will be returned to the analytical laboratory to be tested for posttest contamination levels.

9.2 Once returned to the lab the explosives are removed from the plates using the appropriate solvent. The plates are sonicated in the appropriate solvent. The resulting solution is filtered through a 0.45-micron filter. Solvent contaminated with explosive is then placed in a 2-milliliter crimp-top vial. High Performance Liquid chromatography is used to quantify the explosive in solution. The HPLC eluant is 60:40, acetonitrile: water, the flow rate is 1ml/min, and a C-18 column is used. The system utilizes a diode array

detector monitoring 254 λ. Generally, a five-point calibration is performed using ultra-pure explosive standards. The calibration range is appropriate for the test matrix, generally 1part per million (PPM) to 200 PPM. The calibration curve is linear with-in the test range, and a correlation coefficient of 0.99 or greater is required prior to analysis.

10. Test Procedure for Uniformity of contamination levels.

10.1 A mask will be made and placed on the friction plate over the contamination area Figure 10.1.

10.2 Samples from each friction plate will be taken using a swab saturated with a solvent capable of removing the HMX, presumably acetonitrile (ACN). A minimum of three swabs will be used at each test location to ensure complete extraction see Figure 10.2.

10.3 The three swabs will be transferred to a single scintillation vial and 10-15 milliliters of ACN will be precisely added by a previously calibrated, class A, pipette Figure 10.3. The HMX will be extracted from the swabs by either time dissolution or gentle ultra-sonication. The extraction times will be carefully monitored and recorded to ensure consistent results. Once extracted, the resulting solutions will be filtered through a 0.45 um filter into HPLC autosampler vials and placed in the instrument for analysis.

10.4 The extracted samples will be analyzed by High Performance Liquid Chromatography (HPLC). Analytical standards will be run at the beginning and again at the end of each batch of samples to verify that the relationship between instrument response and HMX concentration remains constant. A batch will consist of all samples taken from a single friction plate: a single injection of procedural blank (X1), duplicate injections of sampling positions (1 – 5), and a single injection of procedural blank (X2). Once the analysis is completed, the concentration of HMX for each position will be calculated and provided for comparison.

10.5 The complete process, mentioned above, would be repeated for all friction plates that are provided to the laboratory for analysis, presumably three (3) friction plates.

NOTE: It should be mentioned that this test is designed to verify homogeneity of the contaminated test area, not the accuracy of the contamination process. The latter would require a complete extraction of the contaminated surface; it is my impression that this has been performed previously.

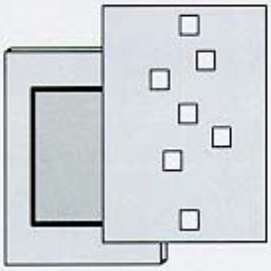


Figure 10.1

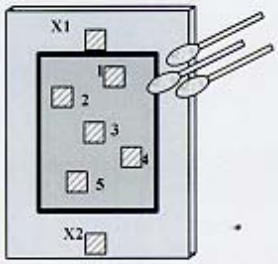


Figure 10.2

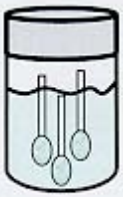


Figure 10.3

11. Hold Fire Criteria

There are minimum criteria that should be met if testing is to occur. For this test they include:

11.1 No pre-test photograph of test item

11.2 Uniform contamination of test samples.

12. Post-Test Requirements

12.1 Data is unofficial until control samples have been analyzed for concentration of explosive.

12.2 All anvils and plates will be visually inspected and all anomalies noted.

12.3 Digital photos of all tested plates and anvils.

13. Data Assessment

The following parameters will be assessed.

13.1 Uniform Contamination of sample

13.2 Level of contamination that causes a reaction.

14. Test Reporting

A technical report of the results will be submitted. The report will be provided by IHDIV, Code 370LA and 370PW, by mid July 2003 and will include:

14.1 Test Description and results.

14.2 Photos

Appendix D

METHOD OF SPIKING PLATES AND ANVILS

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METHOD OF SPIKING PLATES AND ANVILS FOR SENSITIVITY TESTING OF WOOD, CONCRETE, METAL, AND TRANSITE SURFACES CONTAMINATED WITH AMMONIUM PICRATE, TETRYL, NG, NITRONAL, HBNQ, HMX, NC, TATB, TNT, RDX, AND AP

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1.0 Introduction

The purpose document is to establish the method used for contamination of testing plates and anvils with uniform distributions of AMMONIUM PICRATE, TETRYL, NG, NITRONAL, HBNQ, HMX, NC, TATB, TNT, RDX, and AP.

The spiking of plates and anvils was done in accordance with the TEST PLAN TO ASSESS THE SENSITIVITY LEVELS OF CONTAMINATED SURFACES TO ESTABLISH NON-REACTIVITY LEVELS, document number 370/02/109.

2.0 Objective

The objective of this document is to detail the method for spiking uniform explosive levels on the test materials; friction plates, and anvils. These test materials will be used in subsequent sensitivity testing.

3.0 Apparatus

3.1 Impact Test

The anvils supplied by Code 370 personnel were cylindrical in shape, with the dimensions 1.25 inches long with a 1.25 inch diameter. For this test series, the standard steel, type 12 anvil, with the aforementioned dimensions, was replaced with anvils of the same dimensions made of the designated materials, wood, concrete, metal and transite.

3.2 *Friction Test*

The friction plates supplied by Code 370 personnel were of the same dimensions as the standard friction plate, 2.25 by 6 inches. For this test series, the steel type plate was replaced with plates made from the designated materials, wood, concrete, metal and transite.

3.3 ESD Test

The anvils supplied by Code 370 personnel were cylindrical in shape, with the dimensions 0.25 inches long with a 0.25 inch diameter. The anvils used were the standard steel type anvils.

3.4 *Laboratory reagents*

All reagents used were HPLC Grade or better. The reagents used for this test series include acetonitrile, acetone, and methanol and 18 ohm water.

3.5 Other materials

A 1000ul eppendorf pipette or equivalent, digital camera, Olympus D-500L, or equivalent.

4.0 Procedures

4.1 Preparation of spiking solutions

Solutions were prepared using TATB, AP, NITRONAL, TETRYL, NG, NC, HMX, TNT, and HBNQ supplied by Code 310. AMMONIUM PICRATE was obtained from NSWC, Yorktown Division.

The determination of solvent was based on the solubility characteristics of the explosive. Other considerations in solvent selection were the volatility and toxicity of the solvent.

Table 3.1, below lists the explosives, the solvents used and the spiking concentration.

TABLE 3.1

EXPLOSIVE	REFERENCE	SOLVENT	CONCENTRATION
TATB	Lot#98079-135-01	ACETONE	33.14ug/ul
AP	Lot#7406	WATER/ACETONE	11.134
NITRONAL	Tegdn#34-91, tmetn#75-121 Resorcinol#280, EC,Aldrich	ACETONE	4.946
PICRATE	Yorktown	WATER/METHANOL	19.9585
TETRYL	Ref#13771	ACETONE	3.608
NG	Lot#IH230-96-NGTK1-901	ACETONITRILE(ACN)/ ACETONE	6.657
NC	Lot#rad92f100-053	ACETONE/ACN	5.518
HMX	Ref#13934	ACETONE/ACN	3.731
RDX	Lab%28923	ACETONE/ACN	3.919
TNT	Lab%29194	ACETONE/ACN	4.657
HBNQ	Lot#IH91L002-053	METHANOL	3.836

4.2 Determination of concentration

The appropriate volume of solution spiked on the plates or anvils was determined by the following calculation:

[(Contamination level)(Area)]/[Spiking concentration]

For example, using TATB, friction plate with a test area of 40.2cm^2 and contamination level of 200ug/cm^2, the calculated volume of spiking solution is:

[(200ug/cm^2)(40.2cm^2)]/[33.14ug/ul]=242ul

The concentrations of the spiking solutions used are listed on Table 3.1. The area for the large anvil was determined to be 7.54cm^2. The area for the small anvils was determined to be 0.28cm^2.

4.3 Contamination of plates and anvils

The plates and anvils were spiked with the calculated volumes of explosive solutions. A 1000ul eppendorf pipette was used to measure and dispense the explosive solutions. The operation was performed in a laboratory fume hood where solvents were allowed to evaporate at room temperature

4.4 *Documentation*

Surfaces of the spiked anvils and plates were recorded using an Olympus D500L digital camera. The records were transferred to a compact disk and provided to Code 370 personnel.

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Appendix E

METHOD OF EXTRACTION

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METHOD OF EXTRACTION AND ANALYSIS OF EXPLOSIVE RESIDUE ON PLATES AND ANVILS CONTAMINATED WITH EXPLOSIVE FOR SENSITIVITY TESTING

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1.0 Introduction

The purpose of this document is to establish the method used for extraction and analysis of control plates and anvils previously contaminated with explosive.

The extraction and analysis of explosive residue on plates and anvils was done in accordance with the TEST PLAN TO ASSESS THE SENSITIVITY LEVELS OF CONTAMINATED SURFACES TO ESTABLISH NON-REACTIVITY LEVELS, document number 370/02/109.

2.0 Objective

The objective of this document is to detail the method for extraction and analysis of explosive residue on the test materials; friction plates, and anvils. These test materials were controls used in sensitivity testing.

3.0 Apparatus

3.1 Impact Test

The anvils supplied by Code 370 personnel were cylindrical in shape, with the dimensions 1.25 inches long with a 1.25 inch diameter. For this test series, the standard steel, type 12 anvil, with the aforementioned dimensions, was replaced with anvils of the same dimensions made of the designated materials, wood, concrete, metal and transite.

3.2 *Friction Test*

The friction plates supplied by Code 370 personnel were of the same dimensions as the standard friction plate, 2.25 by 6 inches. For this test series, the steel type plate was replaced with plates made from the designated materials, wood, concrete, metal and transite.

3.3 ESD Test

The anvils supplied by Code 370 personnel were cylindrical in shape, with the dimensions 0.25 inches long with a 0.25 inch diameter. The anvils used were the standard steel type anvils.

3.4 *Laboratory reagents*

All reagents used were optima grade. The reagents used for this test series include acetonitrile, acetone, methanol and 18 ohm water. Helium gas tank equipped with Dryrite gas purifier, part number 27068, or equivalent. HPLC grade sodium carbonate, HPLC grade boric acid, 55% tetra-n-butylammonium hydroxide, and ultra-pure concentrated sulfuric acid

3.5 Other materials

Glassware including 100mL volumetric flasks, 25mL volumetric flasks, 20mL scintillation vials, 50mL beakers and 8.5 X 4.5 X 2.5 Pyrex loaf pans. Repipetor capable of delivering a 10mL volume. Syringes and adaptable 45uM filters. Hewlett Packard 1100 series liquid chromatography system equipped with a photodiode array detector. Dionex 500 series ion chromatography system equipped with an anionic conductivity detector. Spectronic 20 Genesis UV-vis single wavelength spectrophotometer. Chromatography columns including; Agilent hypersil ODS, 5um, 2.1 X 100mm, or equivalent, Phenomenex phenogel 5,100 Å, 300 X 7.8mm or equivalent, Ultrastyrogel 10^3 Å or equivalent and Luna 250 X 4.60mm, 5u, C-18 or equivalent. Autosampler vials including 2mL clear crimp-top with Teflon seals, and Dionex 5mL vials with filter caps. Crimper for 2mL vials. Aluminum foil.

4.0 Procedures

4.1 Extraction of explosive from anvils and plates

Friction plates were placed in 8.5 X 4.5 X 2.5 Pyrex loaf pans for extraction of explosive. Impact anvils were placed in a 50mL beaker for extraction of explosive. ESD anvils were placed in 20mL scintillation vials. The plates were covered with 100mL of solvent, impact anvils were covered with 25mL of solvent, and ESD anvils were covered with 10mL of solvent. Appropriate solvents are listed in table 4.1.

All plates and anvils were covered with aluminum foil and allowed to soak in the extraction solvent for a minimum of 24 hours. Solutions were periodically agitated by hand while soaking.

Following extraction, the 100mL of solvent used to extract the explosives from the plates Solvent was quantitatively transferred to a 100mL volumetric flask. The loaf pans were rinsed with the rinse solvent being added to the volumetric flask. Similarly, the 25mL of solvent used to extract the explosives from the impact anvils was added to a 25mL volumetric flask. The beakers were rinsed, and the rinse solvent was added to the volumetric flask.

The extract solutions were brought to volume. An aliquot from each solution was drawn into a syringe and filtered through a 45um filter into the appropriate autosampler vial.

Table 4.1

EXPLOSIVE	SOLVENT
TATB	DIMETHYLFORMAMIDE
AP	WATER
NITRONAL	ACETONITRILE
PICRATE	WATER
TETRYL	ACETONITRILE
NG	ACETONITRILE
NC	TETRAHYDOFURAN
HMX	ACETONITRILE
RDX	ACETONITRILE
TNT	ACETONITRILE
HBNQ	WATER

4.2 Instrumental analysis of explosive extract

A Hewlett Packard 1100 series LC equipped with a photodiode array detector was used in the determination of HMX, RDX, tetryl, TNT, nitranol, and NG. The following are the instrumental parameters:

Column: Luna 250 X 4.60mm, 5u, C-18
Eluant: 70% acetonitrile/30% 18-ohm water
Temperature: ambient
Flow rate: 1mL/min
Wavelength: 215 and 254λ
Injection volume: 10uL

A Dionex series 500 IC was equipped with an anion conductivity detector was used in determination of ammonium perchlorate. The following are the instrumental parameters:

Column: Agilent hypersil ODS, 5um, 2.1 X 100mm
Eluant: 15% acetonitrile
15g boric acid/ 1000mL
2mM tetra-n-butylammonium hydroxide
85% 18 ohm water
degas then add 0.25g sodium carbonate/1000mL
Temperature: ambient
Flow rate: 0.7mL/min
Injection volume: 25uL loop
Regenerant: 3mL ultra-pure sulfuric acid/ 4L 18-ohm water, degas
Regenerant flow: 3mL/min

A Hewlett Packard 1100 series LC equipped with a photodiode array detector was used in the determination of NC. The following are the instrumental parameters:

Columns: Phenomenex phenogel, 100 Å, 300 X 7.8mm, and Ultrastyrogel 10^3 Å
Eluant: Tetrahydrofuran degassed blanketed with He at 3 psi
Flow rate: 1mL/min
Injection volume: 10uL
Temperature: 30C
Wavelength: 211λ

A Spectronic 20 Genesis UV-vis single wavelength spectrophotometer was used for TATB and explosive D analysis. The wavelength used was 422λ.

4.3 Generation *of Standard Curve*

For all of the analysis described in section 4.2 above, a standard curve was generated. The curve consisted of a series of standard solution spikes. Explosive lot numbers used for the standard solutions are listed in Table 3.1 in the document Method of Spiking Plates and Anvils for Sensitivity Testing of Wood, Concrete, Metal and Transite Surfaces Contaminated with Ammonium Picrate, Tetryl, NG, Nitronal, HBNQ, HMX, NC, TATB, TNT, RDX, and AP. The detector response was plotted as a function of concentration. In all cases, the detector response was linear. A correlation coefficient of 0.99 or better was attained for all standard curves. Included in each standard curve was a spike from the standard solutions used in spiking plates and anvils for sensitivity testing.

4.4 Calculation of Yield

The total weight of explosive on the plate, using a plate spiked at 200ug/cm^2 as an example, is calculated as follows:

$$200ug/cm^2 \text{ X } 40.2cm^2 = 8040ug \text{ total}$$

The value, 40.2cm^2 , is the area of the friction plate surface that is spiked with explosive. The standard curves were generated in standard concentration units of parts per million (ppm) of explosive. Therefore, the concentration of explosive expected is calculated as follows:

$$(8040ug/100mL)(1000mL/1L)(1mg/1000ug) = 80.4mg/L$$

From section 4.1, the 100mL, in the above expression, is the volume of extraction solvent used for friction plates. The unit, mg/L , is synonymous with ppm. Therefore, for the friction plate spiked with 200ug/cm^2 , the expected concentration of explosive is 80.4ppm. This information can be used to calculate the expected concentration of explosive for friction plates spiked with other amounts of explosive. The following is an example of such a calculation for a plate spiked with 500ug/cm^2 of explosive:

$$(80.4\text{ppm}/200\text{ug/cm}^2) \text{ X } 500\text{ug/cm}^2 = 201\text{ppm}$$

Table 4.2 lists the expected ppm values for the extractions of all of the explosives from the plates and anvils spiked at different concentrations. The calculations for the anvils are done in the same manor as the calculations described in this section. The area used for the impact anvil calculation is 7.54cm^2 and the area used for the ESD anvil calculation is 0.28cm^2.

Table 4.2

Friction Plate		Impact Anvil		ESD Anvil	
Spike ug/cm^2	Expected ppm	Spike ug/cm^2	Expected ppm	Spike ug/cm^2	Expected ppm
200	80.4	200	60.3	50	1.4
500	201	500	150.8		
750	302	750	226.2		

5.0 Results

5.1 Percent recovery

The expected recovery for all of the spiked test materials is listed in Table 4.2. The extraction solutions were run against standard curves generated as described in section 4.2 and 4.3 of this document. The concentration for each solution was calculated using the equation of the line generated in the standard curve. Results of the concentration were obtained in ppm. Recoveries listed as a percent of the total expected recovery is listed below in Table 5.1.

5.2 Analytical Interference

Explosive D and TATB were both analyzed using a single wavelength detector without prior separation. The correlation coefficients were 0.99 or better for the standard curves generated. Specifically, Explosive D and HBNQ both have absorbance maximums in the yellow region of the visible spectra. The high recoveries are most likely due to interference. A potential interference is the yellow from the oxidation of metal.

The nitranol chromatogram showed some interference in the TMETN and TEGDN peak windows. The EC peak was well separated from the majority of the peaks in the chromatogram; therefore EC was used to quantify the nitranol. Although TMETN and TEGDN standard curves had a correlation coefficient of 0.99 or better, the EC was lower. Nitranol is a mixture of four compounds within a specified range of amounts. Using only one standard source, a correlation better than 0.99 is obtained. The curve could not be verified using a second source standard, therefore the confidence level in the results table is recorded as < 5%.

Table 5.1

Explosive	Test material	Spike (ug/cm^2)	Recovery (%)
Tetryl	Cement Anvil	200	5
Tetryl	Resin Anvil	500	3
Tetryl	Cement Plate	500	3
Tetryl	Resin Plate	500	6.5
HBNQ	Cement Anvil	500	ND
HBNQ	Resin Plate	200	15.5
HBNQ	Cement Plate	286	ND
AP	Resin Plate	750	23
HMX	Cement Anvil	750	52
HMX	Cement Anvil	500	15
HMX	Cement Plate	500	5
HMX	Cement Plate	500	18
TNT	Resin Plate	200	3
NG	ESD Anvil	50	ND
NG	Cement Plate	200	1
NG	Wood Plate	500	42.4
NG	Metal Plate	500	ND
NG	Resin Plate	500	ND
NG	Cement Plate	500	ND
Explosive D	Wood Plate	200	38
Explosive D	Resin Plate	200	8.6
Explosive D	Cement Plate	200	132
Explosive D	Metal Plate	200	12
Explosive D	Resin Anvil	200	103
Explosive D	Wood Anvil	500	14
Explosive D	Cement Anvil	500	65
Explosive D	Metal Anvil	200	125
Nitranol	ESD Anvil	75	ND
Nitranol	Wood Anvil	200	< 5
Nitranol	Resin Anvil	500	< 5
Nitranol	Cement Anvil	200	< 5
Nitranol	Metal Anvil	200	ND
Nitranol	Metal Plate	500	ND
Nitranol	Wood Plate	500	< 5
Nitranol	Cement Plate	500	< 5
Nitranol	Resin Plate	500	< 5
NC	Resin Plate	750	interference
NC	Cement Plate	750	interference
NC	Cement Anvil	200	interference

6.0 Conclusions

Across the range of explosives and materials, the recoveries are very low. It can be anticipated that the porosity of the wood, resin (transite) and cement may lower the recovery. The metal test materials however should have recoveries approaching 100% if the explosive were still on the surface. All of the explosives have some vapor pressure and go off as a gas over time. The process of becoming a gas is hastened by increasing the temperature, or by currents passing over the surface. Further, in the case of TNT, if not the other explosives, there is some photodegradation.

Appendix F

RESULTS OF SENSITIVITY TESTING

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RESULTS OF SENSITIVITY TESTING OF WOOD, CONCRETE, METAL, AND TRANSITE SURFACES CONTAMINATED WITH AMMONIUM PICRATE, TETRYL, NG, NITRONAL, HBNQ, HMX, NC, TATB, TNT, RDX, AND AP

Prepared By

MATERIALS CHARACTERIZATION BRANCH
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INDIAN HEAD DIVISION
NAVAL SURFACE WARFARE CENTER
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March 27, 2003

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Approved by: _____ 7/29/03
Michael Dunn — Date
Deputy Director, Code 30A
Energetics Evaluation Department

TABLE OF CONTENTS

1 Introduction

The purpose of these tests is to assess the sensitivity of contaminated surfaces to establish non-reactivity levels of AMMMONIUM PICRATE, TETRYL, NG, NITRONAL, HBNQ, HMX, NC, TATB, TNT, RDX, and AP on wood, concrete, metal, and transite.

The testing was done in accordance with test plan prepared by Lisa Aliff and Paul Wallman—TEST PLAN TO ASSESS THE SENSITIVITY LEVELS OF CONTAMINATED SURFACES TO ESTABLISH NON-REACTIVITY LEVELS, document number 370/02/109.

2 Objective

The objective of this testing is to determine the minimum explosive concentration level that will cause a reaction on an impact, friction, or ESD machine using various explosives at various contamination levels.

3 Test Apparatus and Hardware

3.1 Impact Test

The apparatus used is the NOS Impact Tester. It uses a 5 kilogram drop weight, type 12 steel striker, and the supplied anvils as described in the test plan.

Type 12 tooling consists of a 1.25 inch diameter by 1.25 inch long cylinder of hardened steel used as an anvil, with a 1.25 inch diameter by 3.5 inch long cylinder of hardened steel used as a striker.

For this test series, the standard type 12 anvil was replaced with anvils of the same dimensions made from the designated materials: wood, concrete, metal, and transite.

For this test series, the drop height used was 1000 millimeters, which is the maximum height available for this impact tester.

3.2 Friction Test

The apparatus used is the ABL Friction Tester. It uses a steel friction wheel, and the supplied friction plates as described in the test plan. The standard plate velocity of 8 feet per second was used.

The friction surfaces consist of a 2 inch diameter by 0.125 inch thick wheel of hardened steel which slides across a 2.25 by 6 inch plate. For each trial, the friction wheel—which is stationary—slides 1 inch across the friction plate.

For this test series, the standard hardened steel friction plate was replaced with plates of the same dimensions made from the designated materials: wood, concrete, metal, and transite.

3.3 ESD Test

The apparatus used is the ABL Electrostatic Discharge Tester. It uses an approaching gap electrode, and operates at 5.8 kilovolts with 12 different capacitor levels.

The sample holder is a 0.25 inch diameter stainless steel pin surrounded by a teflon ring.

For this test series, individual steel pins were supplied, contaminated with various materials.

4 Test Procedures

4.1 Impact Test

In general, SOP P30981 is the procedure used to test materials on the NOS Impact tester. Procedures specific to this test plan are as follows:

4.1.1 Replace the standard steel anvil with the supplied contaminated anvil to be tested.
4.1.2 Place the standard steel striker on the anvil and drop the weight from 1000 millimeters.
4.1.3 Record any of the following as a positive reaction: sparks, flame, smoke, noise beyond ambient impact noise, burn marks, charring. Record the type of reaction when a positive occurs.
4.1.4 If a negative reaction occurs, repeat steps 4.1.2 and 4.1.3 until 10 negative reactions are recorded.
4.1.5 After the test, remove but do not clean the anvil.

4.2 Friction Test

In general, SOP P30979 is the procedure used to test materials on the ABL Friction tester. Procedures specific to this test plan are as follows:

4.2.1 Replace the standard steel friction plate with the supplied contaminated plate to be tested.
4.2.2 Lower the steel wheel onto an untested and contaminated area of the plate and pump the pressure to the desired level.
4.2.3 Drop the pendulum from the 8 feet per second position.
4.2.4 Record any of the following as a positive reaction: sparks, flame, smoke, noise beyond ambient friction noise, burn marks, charring. Record the type of reaction when a positive occurs.
4.2.5 If a negative reaction occurs, repeat steps 4.2.2 through 4.2.4 until 20 negative reactions are recorded.
4.2.6 After the test, remove but do not clean the plate.

The pressure on the plate varied depending on the surface. Metal and transite plates were tested at 980 psig, which is the maximum pressure used on this friction tester. Concrete plates were tested at 180 psig, and wood plates were tested at 100 psig. These lower

pressures were used to ensure that the wheel would slide across instead of dig into the surface.

When a reaction occurred, the 20 TIL method was used to continue the test. For the next trial, the pressure was changed to the next lower level, which is approximately 75% of the previous level. This method was used to confirm that a reaction occurred, and to determine an energy level that did not cause a reaction.

4.3 ESD Test

In general, SOP P30995 is the procedure used to test materials on the ABL Electrostatic Discharge tester. Procedures specific to this test plan are as follows:

4.3.1 Instead of the standard sample holders, use the supplied sample holders that have removable anvils.
4.3.2 Place an untested ESD anvil into the sample holder and place the sample in the tester.
4.3.3 Charge the 0.5 microfarad capacitor (8.33 joules) and discharge the spark into the sample.
4.3.4 Record any of the following as a positive reaction: sparks or flame beyond ambient spark discharge, smoke, noise beyond ambient spark discharge, burn marks, charring. Record the type of reaction when a positive occurs.
4.3.5 Repeat steps 4.3.2 through 4.3.4 until all 20 anvils are tested.

When a reaction occurred, the 20 TIL method was used to continue the test. For the next trial, the capacitance was changed to the next lower level. This method was used to confirm that a reaction occurred, and to determine an energy level that did not cause a reaction.

5 Results

5.1 Description of Results

Refer to the appendices for the raw data from each individual test.

5.1.1 Impact Tests

None of the impact samples exhibited any reactions.

5.1.2 Friction Tests

Only one of the friction samples exhibited any reactions, and that is NC on metal at 750 $\mu g/cm^2$. Sparks were observed at 980, 750, 560, and 420 psig.

5.1.3 ESD Tests

All three ESD samples—AMMONIUM PICRATE, NG, and NITRONAL—had reactions to ESD, but only small reactions were observed with no visible change seen in the test specimens. The reactions were either a yellow flash or yellow sparks.

5.2 Results Tables

5.2.1 Impact Test Results

Table 5.2.1 Impact Test Results

Contaminant	Substrate	Concentration	Result
AMMONIUM PICRATE	steel	50 µg/cm^2	no reactions
		75 µg/cm^2	no reactions
		100 µg/cm^2	no reactions
		200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	wood	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	concrete	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
AP	steel	500 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
HBNQ	steel	750 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	concrete	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
HMX	steel	750 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	concrete	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions

RESULTS OF SENSITIVITY TESTS OF CONTAMINATED SURFACES

NC	steel	500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	concrete	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
NG	steel	50 µg/cm^2	no reactions
		75 µg/cm^2	no reactions
		100 µg/cm^2	no reactions
		200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	wood	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	concrete	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
NITRONAL	steel	50 µg/cm^2	no reactions
		75 µg/cm^2	no reactions
		100 µg/cm^2	no reactions
		200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	wood	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	concrete	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
RDX	steel	500 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions

TATB	steel	750 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	concrete	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
TETRYL	steel	750 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	concrete	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
TNT	steel	200 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions

5.2.2 Friction Test Results

Table 5.2.2 Friction Test Results

Contaminant	Substrate	Concentration	Result
AMMONIUM PICRATE	steel	50 µg/cm^2	no reactions
		75 µg/cm^2	no reactions
		100 µg/cm^2	no reactions
		200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	wood	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	concrete	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions

RESULTS OF SENSITIVITY TESTS OF CONTAMINATED SURFACES

AP	steel	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
HBNQ	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
HMX	steel	75 µg/cm^2	no reactions
		100 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	concrete	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
NC	steel	750 µg/cm^2	REACTIONS: sparks observed
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	concrete	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
NG	steel	50 µg/cm^2	no reactions
		75 µg/cm^2	no reactions
		100 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	wood	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	concrete	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions

RESULTS OF SENSITIVITY TESTS OF CONTAMINATED SURFACES

NITRONAL	steel	50 µg/cm^2	no reactions
		75 µg/cm^2	no reactions
		100 µg/cm^2	no reactions
		200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	wood	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	concrete	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
RDX	steel	75 µg/cm^2	no reactions
		100 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
TATB	steel	500 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	concrete	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
TETRYL	steel	75 µg/cm^2	no reactions
		100 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
	concrete	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions
TNT	steel	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
	transite	200 µg/cm^2	no reactions
		500 µg/cm^2	no reactions
		750 µg/cm^2	no reactions

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5.2.3 *ESD Test Results*

Table 5.2.3 ESD Test Results

Contaminant	Substrate	Concentration	Result
AMMONIUM PICRATE	steel	50 µg/cm^2	reactions *
		75 µg/cm^2	reactions *
		100 µg/cm^2	reactions *
NG	steel	50 µg/cm^2	reactions *
		75 µg/cm^2	reactions *
		100 µg/cm^2	reactions *
NITRONAL	steel	50 µg/cm^2	reactions *
		75 µg/cm^2	reactions *
		100 µg/cm^2	reactions *

* Small yellow sparks and flashes were observed in addition to the normal spark discharge, but no visible changes were seen in the test specimens.

6 Conclusion

Friction testing yielded only one material with reactions—NC on metal at 750µg/cm^2. This material should receive further investigation. It is possible that a larger concentration or some contaminant could have affected the results.

All ESD tests yielded reactions, but these results do not indicate a sensitivity to electrostatic discharge. The reactions described—yellow sparks and yellow flash—can be achieved by a minute quantity of material reacting to the discharge. The lack of any visible change to the test fixture indicates that the reaction was minor, and did not propagate across the surface of the fixture. Testing the ESD anvils for concentration of remaining materials can confirm the amount of material consumed in the test.

10/02/03 16:09 FAX 001

5100
Ser 350DR/293/dr
2 October 2003

MEMORANDUM

From: Steve Sullivan 350
To: Paul Wallman 370PW

Subj: SENSITIVITY TESTING FOR NG CONTAMINATED STEEL PLATES

Ref: (a) Request by P. Wallman, Code 370PW on 30 September 2003.

1. Steel ABL friction plates contaminated with the following materials were tested for friction sensitivity:

contaminant	concentration	results
NG	75 µg/cm2	sparks (at 980, 750, 560, 420, 315, 235, and 180 psig)
NG	50 µg/cm2	sparks (at 980, 750, 560, 420, 315, and 235 psig)
NG	25 µg/cm2	no reactions
NG	10 µg/cm2	no reactions

2. The tests were completed on October 1 and September 11, 2003. Testing was conducted at NSWC Indian Head, in the Hazard Characterization Lab, Building 888.

3. If there are any questions, please call the Hazard Characterization Group at 301-744-4109 or send a FAX at 301-744-4116.

Steve Sullivan, Code 350

checked & certified by Daniel Remmers

cc 350DR

ABL FRICTION TEST

sample name: NG contaminated Steel
sample ID: 75 µg/cm2
sample prep: residue
requester: Lisa Aliff/Paul Wallman
operator: T. Tolson

date: 9/11/03
temperature: 23 °C
relative humidity: 35 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980	1																				sparks
750	1																				sparks
560	0	0	0	0	0	0	1														sparks
420	1																				sparks
315	1																				sparks
235	0	0	0	0	0	0	1														sparks
180	1																				sparks
135	0	0	0	0	0	0	0														
100																					
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: **0** psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvils, in building 888 room 104

ABL FRICTION TEST

sample name: NG contaminated Steel
sample ID: 50 µg/cm2
sample prep: residue
requester: Lisa Aliff/Paul Wallman
operator: T. Tolson

date: 9/11/03
temperature: 23 °C
relative humidity: 38 %

psig	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	comments
980	0	0	1																		spark
750	0	0	0	0	0	0	1														sparks
560	1																				sparks
420	0	0	0	0	0	0	1														sparks
315	1																				sparks
235	0	0	0	1																	spark
180	0	0	0	0																	
135																					
100																					
75																					
55																					
40																					
30																					

1 = positive reaction (fire)
0 = negative reaction (no-fire)

20 TIL Friction: **0** psig

The threshold initiation level (TIL) is the level at which 20 negatives are observed with at least one positive at the next higher level.

Tested on ABL friction tester; at 8 ft/sec, with steel wheels and steel anvils, in building 888 room 104

Appendix G

UNIFORMITY STUDY TEST REPORT

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8000
Ser 310JT/53/jnt
16 December, 2002

MEMORANDUM

From: 310JT
To: 370LA (Lisa Aliff)
Via: 310

Subj: UNIFORMITY STUDY OF HMX CONTAMINATED FRICTION PLATES

(a) Memo 370LA/96/lla dtd Oct. 02
(b) Testing Plan (HMX2.doc) transmitted by email on 5 Nov. 2002
(c) Memo 370LA/97/lla dtd Oct. 02

1. At your request, reference (a), a uniformity of contamination study was performed on three friction plates contaminated at: 500 ug/cm^2, 100 ug/cm^2, and 50 ug/cm^2. A general testing plan and cost estimate for the effort, reference (b) - HMX2.doc, was provided by email on November 5, 2002. The study was completed 13 December, 2002; this MEMO serves as the official reporting of the results obtained.

2. The three friction plates used in the uniformity of contamination study, shown below, were previously prepared by a separate analyst, per reference (c).

The white crystals of HMX can be visually seen on the 500 ug/cm^2, 100 ug/cm^2, and to some degree on the 50 ug/cm^2 plate. This visual inspection provides a quick, initial indication of the degree of uniformity of contamination across the marked off areas. A more detailed surface analysis using recently acquired imaging software will follow as potential explanation for the analytical results obtained in this study.

Subj: UNIFORMITY STUDY OF HMX CONTAMINATED FRICTION PLATES

3. As outlined in the proposed testing plan, seven (7) samples were to be removed from each friction plate: five (5) samples from the contaminated areas marked in black, and two (2) samples from the uncontaminated areas immediately above and below the marked off rectangles. A sampling template, shown below, was provided by code 370 to identify and isolate the positions of interest. Operationally, the template was placed over each



friction plate, as illustrated above. The template was carefully cleaned with organic solvent, acetonitrile, after each use to prevent cross contamination. A dimensional analysis of each openings on the template, using a digital caliper, revealed an average diameter of 1.274 cm (StdDev = 0.006 cm), and thus a calculated area of 1.28 cm^2. This calculated area will be used later to determine the levels of HMX contamination in ug/cm^2.

4. Originally, it was proposed that samples from each test block be removed using a minimum of three sampling swabs saturated with a solvent capable of removing the HMX, presumably acetonitrile (ACN). The three swabs would then be transferred to a single scintillation vial and extracted with 10-15 milliliters of ACN. Once extracted, the resulting solutions will be filtered through a 0.45 um filter into HPLC auto sampler vials, and analyzed by High Performance Liquid Chromatography (HPLC).

Prior to utilizing this proposed sampling protocol on actual test samples, the procedure was evaluated on surfaces contaminated with HMX at 500 ug/cm^2, 100 ug/cm^2, and 50 ug/cm^2 levels. Since an uncontaminated friction plate was not available, watch glasses were selected to simulate the smooth surface of the friction plates. Contamination at the 500 and 100 ug/cm^2 levels were made by adding 250 ul and 50 ul of a freshly prepared 2.016 ug/ul HMX stock solution to each watch glass surface, respectively. Contamination at the 50 ug/cm^2 level was made by the addition of 50 ul of a 1.030 ug/ul HMX stock solution to the watch glass.

As proposed, HMX was removed from each watch glass using three (3) sampling swabs saturated with ACN. The three swabs were subsequently transferred to a single scintillation vial and precisely 15 milliliters of ACN was added by a previously calibrated, class A, pipette. In addition to samples from the contaminated surfaces, procedural blanks consisting of three clean swabs were also prepared to identify any potential HMX contamination in the procedure (swabs or solvent) and interferences to the analysis. The HMX was extracted from the swabs by gentle ultra-sonication for thirty (30) minutes. The extracted solutions were then filtered through a 0.45 um filter into HPLC auto sampler vials and placed in the HPLC for analysis.



Subj: UNIFORMITY STUDY OF HMX CONTAMINATED FRICTION PLATES

The results from this preliminary evaluation are summarized below:

	HMX (215 nm)		HMX (230 nm)	
Injection	area	height	area	height
QC (5.15)	5.74	5.68	5.63	5.66
	5.72	5.67	5.62	5.65
ave	111.24	110.11	109.21	109.82
X1	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00
ave	0.00	0.00	0.00	0.00
X2	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00
ave	0.00	0.00	0.00	0.00
X3	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00
ave	0.00	0.00	0.00	0.00
SPK 1	443.47	444.87	445.84	446.01
515	443.24	439.92	440.27	439.63
ave	86.09	85.90	86.03	85.98
SPK 2	92.59	89.05	88.75	87.96
100.8	92.99	89.76	88.67	88.70
ave	92.06	88.70	88.00	88.33
SPK 3	49.56	46.72	45.90	45.73
51.4	46.87	46.08	45.35	45.74
ave	93.80	90.27	88.76	88.98
QC (5.15)	5.91	5.76	5.65	5.69
	5.60	5.62	5.62	5.64
ave	111.70	110.49	109.37	110.02
SPK 1 = 85.9		SPK 2 = 88.7		SPK 3 = 90.3
		Average Recovery = 89.4		

As can be seen, the procedural blanks (X1, X2, and X3) did not show any HMX contamination, and there were no significant interferences observed in the chromatographic field. The average recovery for the spikes at 515 ug/cm^2, 100.8 ug/cm^2, and 51.4 ug/cm^2 (SPK1, SPK 2, and SPK 3, respectively) was approximately 89.4 %. An observation made during the test extractions, namely that ACN from the saturated swabs tended to wick away from the swab and pool on the watch glass surface, might provide some explanation for the low recovery. Although the swab was always capable of reabsorbing the solvent, HMX could potentially have been dispersed by that process.

In order to address the issues above, the following changes were made to the sample extraction procedure. First, four (4) sampling swabs would be used for all future extractions rather than three (3). Second, each saturated swab would be blotted on a clean ChemWipe to remove excess solvent prior to its use. These changes increased the average recovery of spiked samples to approximately 94.9 %. The specific results are tabulated in paragraph 6, along with the results for the individual test plates.

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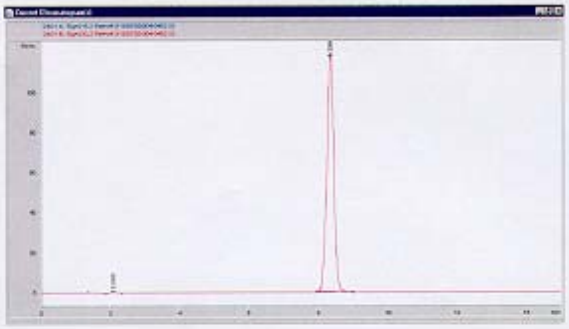
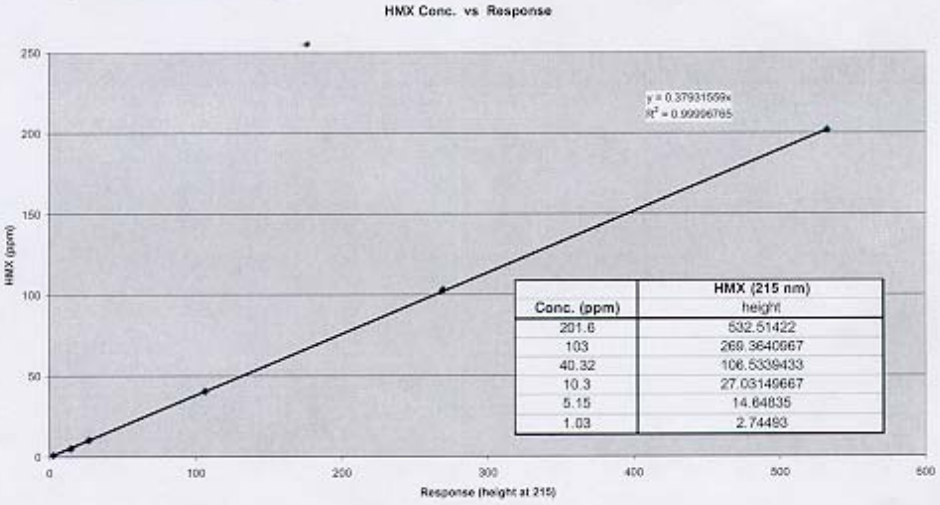
5. High Performance Liquid Chromatography (HPLC) was used to evaluate the HMX content of the extracted samples. The specific analytical conditions are given below:

- HP 1100 series Liquid Chromatograph w/PDA
- Auto Injector: 10 ul injection volume
- Restek: Allure C18 5 um, 250 x 4 mm, analytical column
- 40:60 ACN/H2O Mobile phase at 1 ml/min flow
- Column Oven at 35 degrees centigrade
- UV detector: 215 nm and 230 nm; PDA scan from 190 nm to 600 nm.

A sample chromatogram is provided, the peak at 8.3 minutes is HMX.



Prior to the analysis of the test specimens, the analytical method was validated across the anticipated concentration range of the samples (1 ppm to 200 ppm); six (6) analytical standards prepared at roughly 200, 100, 50, 10, 5, and 1 ppm were introduced into the chromatographic system. The figure below illustrates that the relationship between HMX concentration and height response at a wavelength of 215 nm is linear across the expected concentrations range.



Conc. (ppm)	HMX (215 nm) height
201.6	532.51422
103	269.3640967
40.32	106.5339433
10.3	27.03149667
5.15	14.64835
1.03	2.74493

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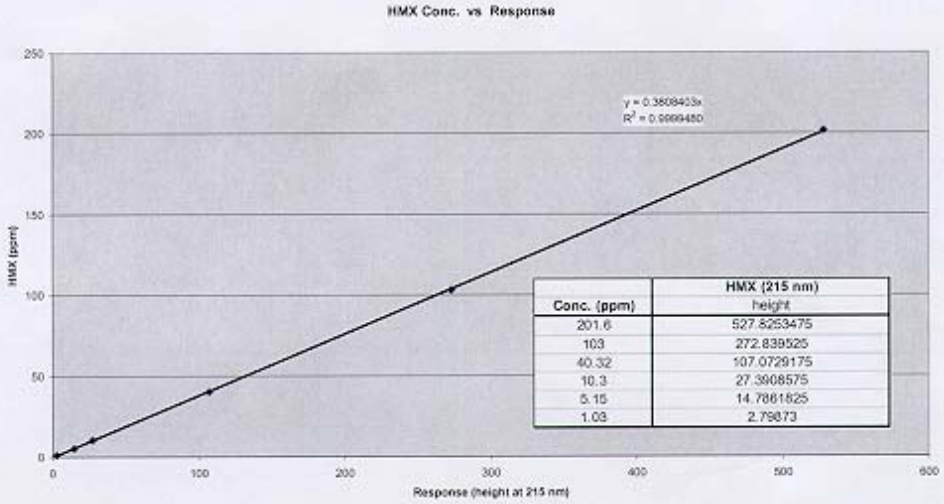
The r^2 value, an indicator of the degree of correlation between two data sets, was determined to be 0.99996765. It should be noted that an r^2 value of 1.000000 denotes a perfect correlation.

6. With the sampling technique and analytical method validated, the 500 ug/cm^2, 100 ug/cm^2, and 50 ug/cm^2 friction plates were extracted and analyzed. The linearity of the method was again verified across the anticipated concentration range using the six (6) analytical standards, previously prepared. Duplicate injections of each standard were made at both the beginning and end of the analytical run. The average of the four determinations was used to establish the concentration curve, shown below, as well as the response factor used for the sample calculations.



Conc. (ppm)	HMX (215 nm) height
201.6	527.8253475
103	272.839525
40.32	107.0729175
10.3	27.3908575
5.15	14.7861825
1.03	2.79873

It should be noted that the average responses for each standard did not deviate significantly from the previous run, and the newly obtained r^2 value of 0.9999480 indicates that linearity was conserved.

Within the total run, each friction plate was analyzed as its own unique analytical batch. In this particular case, an analytical batch consisted of: a procedural blank, a method spike, and all seven (7) samples taken from a single test plate. In addition to the initial linearity check for the total run, analytical check standards were run at the beginning, in the middle, and at the end of each batch of samples to verify that the relationship between instrument response and HMX concentration remained constant. All check standards agreed within 3.0 % of the true value, and in no cases were more than ten (10) injections made between check standards.

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The results of the analysis are summarized in the table below.

Sample	HMX (ug/cm2)	HMX (ug/cm2)	HMX (ug/cm2)
Method Blank	0	0	0
Spike	483 or 93.8 %	96.5 or 95.7 %	49.9 or 96.8 %

Sampling Position	HMX (ug/cm2) 500 ug/cm2 Plate	HMX (ug/cm2) 100 ug/cm2 Plate	HMX (ug/cm2) 50 ug/cm2 Plate
X1	< 1.5	0	0
1	65	13	8
2	43	18	8
3	50	22	8
4	86	18	9
5	50	12	3
X2	0	0	0
Average	59	17	7
Standard Dev.	17	4	2
%RDS	29%	24%	29%

7. At first glance, two observations regarding the data are apparent. First, the results obtained are consistently and significantly lower than the expected values: 500 ug/cm^2, 100 ug/cm^2, and 50 ug/cm^2. Second, there is notable variation in HMX concentration between the five positions sampled within a single contaminated plate.

Explanation for the lower than expected values can be found in the initial contamination of the three friction plates; a careful review of available laboratory records revealed an error in the initial contamination process. Records showed that the stock solution of HMX used to contaminate the plates was prepared by dissolving 0.3731 grams of HMX in 100 ml of organic solvent, resulting in a 3.731 ug/ul solution. Subsequently 575 ul, 115 ul, and 57.5 ul of stock solution was applied to the marked off areas of the 500 ug/cm^2, 100 ug/cm^2, and 50 ug/cm^2 plates, respectively. According to calculations:

[(Concentration of Stock Sol'n)*(Volume of Stock Applied)]÷[(Volume of Contaminated Area)]

[(3.731 ug/ul)*(575 ul)]÷[(39.8 cm2)] = **54 ug/cm^2**

the true or actual contamination levels of the plates provided for the uniformity study were: 54 ug/cm^2, 11 ug/cm^2, and 5.4 ug/cm^2. As you will notice, these values agree more closely with the experimentally determined values.

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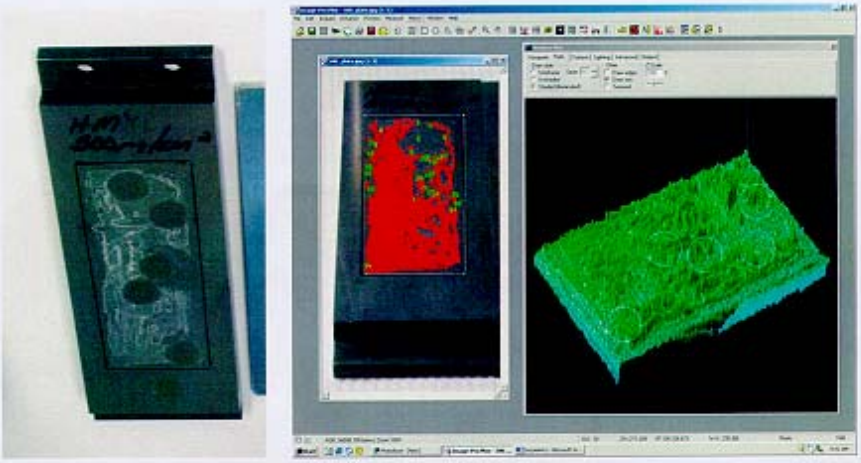
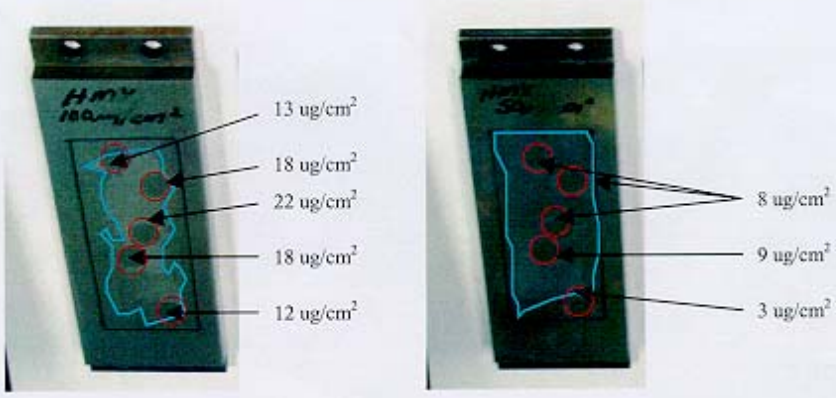
Possible explanation for the variability observed in the study can be found in a more detailed look at the contaminated plates themselves. As noted in paragraph 2, visual inspection provides the first indication of non-uniformity of explosive contamination across the designated test areas. This is most prominent in the 500 ug/cm^2 friction plate. A detailed surface analysis, utilizing imaging software, provides a slightly more quantitative picture of this phenomenon. As shown below, the imaging software is able to identify the white crystals of HMX (shown in red) and provide a density map based on color intensity (histogram, shown in green).



As interpretation, areas with peaks protruding out of the plane on the relief map correlate with stronger color intensities, and thus higher concentrations of HMX. Although without extensive calibration this technique is semi-quantitative at best, locating the extracted areas on the density map (blue circles) does provide some insight into the variability in HMX concentration observed on the 500 ug/cm^2 test plate. As an example, sample position two (2) – the second circle from the right is located in an area with less HMX, according to the relief map, than sample position four (4). This agrees with the experimental results: SN 2 = 43 ug/cm2 and SN 4 = 86 ug/cm2.

In a similar fashion, a closer look at the 100 ug/cm^2 and 50 ug/cm^2 friction plates, also offers plausible explanation for the experimental results obtained. For example, although the HMX contamination on these



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two plates appears more uniform than observed on the 500 ug/cm^2 plate, it does not appear to be distributed across the entire marked off area. If this is in deed the case, a very crude estimation reveals that only about 60 % of the total area marked off on the 100 ug/cm^2 plate would be contaminated with HMX (80% for the 50 ug/cm2 plate). This would increase the HMX concentration at the points of contamination on the 100 and 50 ug/cm^2 plates from a previously calculated 11 ug/cm^2 and 5.4 ug/cm^2 to approximately 18 ug/cm^2 and 7 ug/cm^2, respectively. In addition, based on the location of the extracted samples, high lighted by red circles, the HMX concentrations obtained for positions 1 and 5 on the 100 ug/cm^2 plate and position 5 on the 50 ug/cm^2 plate should be lower than the other sampled positions. Both are consistent with the experimental results.

8. If you have any further questions, please contact James Thomasson at 4159/4812.

JAMES N. THOMASSON III

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